



JCAA/JG-PP Lead-Free Solder Project: Thermal Shock Test

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1.0 Abstract

Thermal shock testing was conducted by Boeing Phantom Works (Seattle) for the Joint Council on Aging Aircraft/Joint Group on Pollution Prevention (JCAA/JG-PP) Lead-Free Solder Project under contract BM3419-01. The JCAA/JG-PP Consortium is the first group to test the reliability of lead-free solder joints against the requirements of the aerospace/military community.

The solder alloys selected for test were:

Sn3.9Ag0.6Cu for reflow and wave soldering

Sn3.4Ag1.0Cu3.3Bi for reflow soldering

Sn0.7Cu0.05Ni for wave soldering

Sn37Pb for reflow and wave soldering

Test vehicles were assembled using these solders and a variety of component types. Thermal shock cycling was then conducted on the test vehicles using a system with dual chambers. The hot chamber was held at 125°C and the cold chamber was held at -55°C. The dwell time in each chamber was 15 minutes and the duration of each test was 1000 cycles.

The solder joints on the components were electrically monitored using event detectors and any solder joint failures were recorded on a Labview-based data collection system. The failures of a given component type attached with SnPb solder were then compared to the failures of the same component type attached with lead-free solders by using Weibull analysis.

2.0 Background

Recently, legislation has been passed in Europe to ban the use of lead (and other materials) in new electronics starting 1 July 2006. The legislation actually banning lead is called the RoHS (Restriction of Hazardous Substances). The legislation that governs the re-use and recycling of electronics waste is called the Waste from Electrical and Electronic Equipment (WEEE) Directive.

Japan also has become focused on lead-free electronics. Many of the major electronics companies (e.g., Hitachi, NEC, NTT, Panasonic) have announced lead reduction targets and the move to lead-free electronics is supported by JEITA (the Japan Electronics and Information Technology Industries Association). These companies view lead-free as a marketing tool that will allow them to gain market share from their foreign competitors.

Aerospace and military electronics are currently exempt from the European legislation. However, as the international commercial electronics industry changes over to lead-free technology in order to satisfy the European legislation, it will become increasingly difficult for aerospace and military programs to procure electronics made with SnPb solder. For this reason, a DoD sponsored consortium was founded in May of 2001 to evaluate lead-free solders and finishes and to determine whether they are suitable for use

in high reliability electronics. This consortium is jointly managed by the Joint Council on Aging Aircraft (JCAA) and the Joint Group on Pollution Prevention (JG-PP). The consortium's project is called the JCAA/JG-PP Lead-Free Solder Project and it boasts members from all branches of the Armed Services, NASA, Boeing, Rockwell-Collins, Raytheon, BAE Systems, ACI, Lockheed Martin, Texas Instruments, NCMS, Sandia National Labs, and Marshall Space Flight Center among others.

The consortium wrote a test plan called the Joint Test Protocol (JTP, Reference 1) which describes the testing to be done. The testing includes thermal cycling, thermal shock, vibration, mechanical shock, combined vibration/thermal cycling, electromigration, SIR, salt fog and humidity.

A test vehicle was designed and the lead-free solders to be tested were chosen. The solder selection process was documented in the Potential Alternatives Report (PAR, Reference 2).

The test vehicle was a six-layer circuit board 14.5 inches wide by 9 inches high by 0.090 inches thick (Figure 1). A break-off coupon populated with chip resistors and chip capacitors was attached to one side of the main test vehicle. With the break-off coupon removed, the main test vehicle was 12.75 in. by 9 inches in size and was populated with 55 components consisting of ceramic leadless chip carriers (CLCC's), plastic leaded chip carriers (PLCC's), TSOP's, TQFP's, BGA's, and PDIP's (Figure 2). The pads for the CSP's and the hybrids were not populated. The components contained internal wire bonds so that once mounted on the test vehicle, each component would complete an electrical circuit that could be monitored during testing. Failure of a solder joint would cause a break in the electrical circuit that could be detected by an event detector. Each test vehicle also had a daisy-chain of twelve 0.016 inch diameter plated thorough holes so that the reliability of the holes could be determined. The plated through holes were filled with solder during the wave solder operation. Each component location on the test vehicles was given a unique reference designator number.

The solder alloys selected for test were:

Sn3.9Ag0.6Cu for reflow and wave soldering (abbreviated as SAC)

Sn3.4Ag1.0Cu3.3Bi for reflow soldering (abbreviated as SACB)

Sn0.7Cu0.05Ni for wave soldering (abbreviated as SnCu)

Sn37Pb for reflow and wave soldering (abbreviated as SnPb)

The SAC alloy was chosen because extensive testing by NEMI suggests it is a viable candidate for use in lead-free commercial electronics. The SACB alloy was chosen because it was the best performer in the large 2001 NCMS study (Reference 3). The SnCu alloy was chosen because it has been widely used in Asia with good results. Finally, SnPb was included to act as the control alloy.

The test vehicles were divided into two types. The first type (named "Manufactured" test vehicles) were made using a laminate with a high glass transition temperature (Tg of 170

degrees C) and an immersion silver board finish. The “Manufactured” test vehicles were meant to be representative of a printed wiring assembly (PWA) designed for manufacture using lead-free solders and lead-free reflow and wave soldering profiles. Tables 1 and 2 list the components used on the “Manufactured” test vehicles and “Manufactured” control test vehicles; the finish on each component; and the solders used. The CLCC’s with a lead-free pad finish were produced by robotic dipping of gold-plated CLCC’s into the respective molten solders (Sn3.9Ag0.6Cu or Sn3.4Ag1.0Cu3.3Bi). The robotic dipping was done at Corfin Industries in Salem, NH.

The second type (named “Rework” test vehicles) were made using a laminate with a low glass transition temperature (T_g of 140 degrees C) and a tin/lead HASL board finish. The “Rework” test vehicles were meant to be representative of a typical tin/lead PWA that will have to be reworked using lead-free solders in the future. The “Rework” test vehicles were initially built using tin/lead solder and a tin/lead board finish and using typical tin/lead reflow and wave soldering profiles. Selected components on the “Rework” test vehicles were then removed; residual tin/lead solder was cleaned from the pads using solder wick; and new components were attached using a lead-free solder. Components on the “Rework” control test vehicles were reworked with tin/lead solder rather than a lead-free solder. In general, solder wire was used for reworking the components. The BGA’s, however, were replaced using flux only and the balls were reflowed using a hot air rework station to form the solder joints. Tables 3 and 4 list the components used on the “Rework” test vehicles and “Rework” control test vehicles; the finish on each component; the solders used; and which components were actually reworked.

Two hundred and five test vehicles were assembled at Boeing’s plant in Irving, Tx (now BAE Systems). One hundred and nineteen of these test vehicles were “Manufactured” PWA’s and eighty six were “Rework” PWA’s. Eight components were reworked on each of the “Reworked” test vehicles (two BGA’s; two TSOP’s; two PDIP’s; and two TQFP-208’s). Thirty of the assembled test vehicles were sent to Boeing in Seattle for thermal shock testing. These PWA’s consisted of 15 “Manufactured” test vehicles and 15 “Rework” test vehicles.

The reflow profiles used for the SnPb and the lead-free solder pastes are shown in Figures 3 and 4. A 6-mil laser cut stencil was used during paste application. The wave soldering profiles used for tin/lead and lead-free wave soldering are shown in Figures 5 and 6. Wave soldering with SnPb was done at Boeing-Irving and the lead-free wave soldering was done at Vitronics-Soltec in New Hampshire. The rework profiles for removing and replacing the BGA’s using a hot air rework station are shown in Figures 7 and 8. All rework was done at Boeing-Irving.

On the “Manufactured” test vehicles, some CLCC’s were finished with SnPb (on the pads and in the castellations) which resulted in lead-free solder joints contaminated with Pb after assembly (i.e., components U9, U13, U22, U46 and U53). In addition, some of the TSOP’s had a SnPb finish which also resulted in lead-free solder joints contaminated with Pb (i.e., components U16, U24, U26, U40 and U62). This mixing was done

intentionally in order to determine the effects of lead-contamination upon lead-free solder reliability. Inductively coupled plasma (ICP) spectroscopy was used by Boeing to quantify the amount of Pb in the solder joints on two of the “Manufactured” test vehicles (see Table 5; Test Vehicle ID #'s 80 and 119). The solder joints were removed with a scalpel, dissolved in acid, and the solution was analyzed by ICP spectroscopy.

Similarly, on the “Rework” test vehicles, all of the solder joints contained Pb. The components that were reworked using lead-free solders picked up residual Pb from the pads on the test vehicles (i.e., TSOP's U12 and U25; BGA's U4 and U18; PDIP's U23 and U59; and TQFP-208's U3 and U57). Other components had lead-free finishes but since they were attached to the “Rework” test vehicles using SnPb solder, the final solder joints contained large amounts of Pb (CLCC's U9, U10, U13, U14, U17, U22, U45, U46, U52, U53; and BGA's U2, U5, U6, U21, U43, U44, U55, U56). Again, inductively coupled plasma (ICP) spectroscopy was used to quantify the amount of Pb in the solder joints on two of the “Rework” test vehicles (see Table 5; Test Vehicle ID #'s 158 and 186).

All of the ICP analyses appeared reasonable with the possible exception of the QFP-208 analysis. The copper content in the QFP-208 solder joints was 6.63% which is higher than expected. It is possible that the excess copper was removed from the test vehicle pads when the solder joints were cut from the test vehicle using a scalpel.

3.0 Objective and Approach

The objective of this study was to determine the effects of thermal shock cycling on the relative reliability of lead-free and tin/lead solder joints (i.e., which solder survived the longest).

Thirty test vehicles were delivered to Boeing for thermal shock testing. These consisted of 15 “Manufactured” test vehicles and 15 “Rework” test vehicles.

The break-off coupons (populated with 10 chip resistors and 300 chip capacitors) were removed from the main test vehicles. The test vehicles and break-off coupons were tested in four groups due to the size limitations of the thermal shock chamber. The four groups consisted of:

1. Eight “Manufactured” vehicles (ID #'s 1, 10, 80-82, 119-121)
2. Seven “Manufactured” vehicles (ID #'s 11, 12, 14, 83, 84, 122, 123) plus six break-off coupons from the “Manufactured” test vehicles (ID #'s 1, 10, 80, 81, 119, 120)
3. Eight “Rework” vehicles (ID #'s 51, 52, 158-160, 186-188)
4. Seven “Rework” vehicles (ID #'s 53, 54, 55, 161, 162, 189, 190)

Each group contained test vehicles assembled with the lead-free solder candidates and vehicles assembled with the SnPb control solder.

Figure 9 shows the Ransco vertical thermal shock chamber used for this test. The test vehicles were mounted in an elevator with a volume of 10.4 cu.ft. The elevator was cycled between a hot chamber and cold chamber with a transition time of approximately 5 seconds. For this test, the hot chamber was held at 125°C and the cold chamber was held at -55°C. The dwell time in each chamber was 15 minutes and the duration of each test was 1000 cycles. Figure 10 shows actual air and test vehicle temperatures during the test.

The chamber was fitted with signal wires to monitor up to 512 channels. Each of the 55 components on each test vehicle were individually monitored using Analysis Tech 256STD Event Detectors (set to a 300 ohm threshold) combined with Labview-based data collection software. In addition, the ten 1206 chip resistors on each break-off coupon were individually monitored. The chip capacitors on the break-off coupons were not electrically monitored.

Figure 11 shows the eight “Manufactured” test vehicles mounted in a rack before insertion into the thermal shock chamber.

4.0 Results and Discussion

After completion of all thermal shock testing, the “Manufactured” and “Rework” test vehicles were visually inspected using a HYROX Hi-Scope Compact Micro Vision System (Model KH-2200 MD2). Photographs of representative CLCC and TSOP solder joints and solder joint failures are shown in Figures 12 through 29 (all photographs were taken after 1000 thermal shock cycles).

For those component types that had a significant number of failures, Weibull plots of the failure data were created to determine the beta (slope) and the characteristic lifetime (time to fail 63.2% of the population, also called alpha) for each component type.

Using the following equation, the number of cycles required to fail a specific percentage of components, F(t), can be calculated if alpha and beta are known.

$$t_p = \alpha [-\ln\{1-F(t)*0.01\}]^{1/\beta}$$

Components that were electrically open before the testing began are shown in Tables 6 and 7. Early and miscellaneous component failures are shown in Tables 8 and 9. These failures are not shown on the Weibull plots.

The raw test data can be found in Appendices B and C.

4.1 Observations (“Manufactured” Test Vehicles)

Components that were electrically open before the testing began are shown in Table 6. The PDIP, TQFP, and TSOP opens appeared to be due to missing internal wire bonds as

determined by using an ohmmeter to trace electrical continuity. The exception was PDIP U63 which had two leads that were not soldered. The cause for the open within BGA U5 was not determined.

The only components that had enough failures to produce meaningful Weibull plots were the CLCC's and those TSOP's with a SnPb finish soldered with SnAgCuBi. The early failure of the TSOP's is presumably due to the formation of a low melting ternary 16Sn32Pb52Bi alloy (m.p. 96°C, Reference 4).

4.1.1 CLCC-20's

A large percentage of the CLCC's failed during the test. Weibull plots of the data (Figure 30) show that the combination of SnPb paste/SnPb part finish slightly outperformed the combination of SACB paste/SACB part finish which in turn outperformed SAC paste/SAC part finish. These results are similar to those found in the published literature (Reference 4).

In those cases where the CLCC's were finished with SnPb and were combined with either SAC paste or SACB paste, the lead contamination in the final solder joints had only a slightly negative effect on the survival times of the solder joints (see Figure 31). This is surprising as bismuth alloys combined with trace amounts of lead have been shown to fail prematurely in thermal cycling due to the formation of a low melting ternary 16Sn32Pb52Bi alloy (m.p. 96°C). In addition, trace amounts of lead have been shown to have a positive effect on the survival times of SAC solder joints (Reference 4). The large amount of lead in the CLCC solder joints in this study (approx. 17% by ICP analysis) appear to have a very different effect on solder reliability than do trace amounts of lead (see the TSOP results below). The large amount of lead in the solder joints is due to the large amount of SnPb solder held by the castellations on each CLCC.

4.1.2 TSOP-50's

The only TSOP's to have significant failures in this study were those with a SnPb finish and soldered with SACB. The early failure of the TSOP's soldered with SACB is presumably due to the formation of a low melting ternary 16Sn32Pb52Bi alloy (m.p. 96°C). The amount of Pb in these solder joints was approximately 3% as determined by ICP spectroscopy. This result is in contrast to the CLCC data, where large amounts of lead contamination had only a slightly negative effect on the reliability of SACB.

SACB solder combined with a SnCu part finish had no failures at 1000 thermal shock cycles. The other combinations of solders and part finishes had some failures at 1000 cycles but they were too few to produce definitive Weibull plots (see Figure 32).

Some of the SAC solder joint failures appeared to be early (infant mortality) failures and were excluded from the Weibull plots. These failures are shown in Table 8.

4.1.3 BGA-225's

SnPb balls assembled with SAC paste failed on six out of a total of 25 BGA's (see Table 8). No Weibull analysis was done since the number of failures was less than 25% of the population. These failures suggest that using SnPb BGA's in combination with SAC solder is to be avoided. In comparison, only one failure was seen when SACB paste was used with SnPb balls.

No failures were observed for the combinations of SnPb paste/SnPb balls; SAC paste/SAC balls; or SACB paste/ SAC balls.

4.1.4 PDIP-20's

Only three failures were observed (see Table 8). Two of the failures were SnPb solder combined with a NiPdAu part finish.

4.1.5 PLCC-20's

No failures were observed.

4.1.6 TQFP's

Only one failure was observed (see Table 8).

4.1.7 Plated Through Holes (PTH's)

No PTH failures were observed.

4.2 Observations ("Rework" Test Vehicles)

The "Rework" test vehicles had a SnPb HASL finish on the pads and they were initially assembled with SnPb solder. During rework, the old component was removed; the pads were wicked clean of most but not all of the SnPb; and a new component was attached using a lead-free solder. Therefore, all solder joints on the "Rework" vehicles contain lead, even the components that were reworked (see Table 5). In addition, the effects of lead contamination and the effects (if any) of the heat of the rework operation upon the reliability of the solder joints in this test are not separable from each other.

Components that were electrically open before the testing began are shown in Table 7. The opens appeared to be due to missing internal wire bonds.

The only components that had enough failures to produce meaningful Weibull plots were the CLCC's; the TSOP's; the BGA's with SAC balls soldered with SnPb; and TQFP-208 U3 (which was reworked).

4.2.1 CLCC-20's

A large percentage of the CLCC's failed during the test. Weibull plots of the data (Figure 33) show that the combination of SnPb paste/SnPb part finish greatly outperformed the combination of SnPb paste/SAC part finish which in turn slightly outperformed SnPb paste/ SACB part finish. The results suggest that using SnPb solder paste in combination with either lead-free CLCC finish should be avoided.

The lead-free part finishes were not expected to reflow during assembly (which used a SnPb reflow profile). Chemical analysis of the fillets of the final solder joints (but not material from inside the CLCC castellations) revealed that the joint fillets contained Ag (see Table 5). This suggests that some mixing of the lead-free finishes and the SnPb paste occurred during reflow. Microsections need to be done to verify that mixing occurred.

4.2.2 TSOP-50's

All combinations of solders/part finishes had enough failures to generate Weibull plots, i.e., SnPb/SnPb; reworked SnPb/SnPb; SnPb/SnCu; reworked SAC/SnCu; and reworked SACB/SnCu (see Figure 34).

SnPb/SnPb solder joints and SnPb/SnCu solder joints had equivalent reliability.

Rework of SnPb solder joints with SACB or SnPb yielded solder joints that were much less reliable than the original SnPb joints. The reason that the SACB had poor performance was probably due to the formation of the low melting ternary 16Sn32Pb52Bi alloy. It is not clear why the reliability of the solder joints reworked with SnPb was degraded. It is possible that the wetting of the pads by the SnPb solder during rework was inhibited due to the formation of a thick intermetallic layer during removal of the component. Microsections need to be done to better understand this observation.

The SnPb solder joints that were reworked with SAC are as reliable as the original SnPb solder joints. This is similar to the relative solder reliability ranking observed during the testing of the TSOP's on the "Manufactured" test vehicles (see Figure 32, caution must be used since only a few failures were observed for the SAC/SnCu solder joints).

4.2.3 BGA-225's

The only BGA failures were for the combination of SnPb solder with SAC balls (Figure 35). The results suggest that using SnPb solder paste in combination with either SAC balls should be avoided.

The lead-free part finishes were not expected to reflow during assembly (which used a SnPb reflow profile). Microsections need to be done to verify if mixing occurred.

4.2.4 PDIP-20's

Only one PDIP failed during the test (see Table 9).

4.2.5 PLCC-20's

No PLCC failures were observed.

4.2.6 TQFP's

The only TQFP failures were with TQFP-208 U3 which had been reworked with either SAC or SACB (Figure 36). TQFP U3 and the adjacent BGA's (U4 and U18) were removed at the same time during rework. It is believed that heat from the replacement of the BGA's prior to replacement of TQFP U3 affected the U3 pads resulting in weak pad/solder interfaces. Microsections need to be done to better understand this observation.

The other TQFP-208 that was reworked (U57) did not exhibit any failures which suggests that the premature failure of U3 is not due to the solders used but is due to some rework variable (rework temperature, time at rework temperature, % Pb contamination, etc.).

4.2.7 Plated Through Holes (PTH's)

No PTH failures were observed.

4.3 Published Reliability Data

A literature search was conducted to collect published Weibull parameters for SnPb and lead-free solders (mainly SAC) used with various component types. The results of the search can be found in the Table in Appendix A. In general, the published CLCC reliability data is in agreement with the data from the current test (i.e., SnPb is more reliable than SAC).

The data from the literature search showed that SnPb solder outperforms SAC when the solders are used with components made from ceramic (e.g., CLCC's) or Alloy 42 (TSOP's) and tested using an aggressive thermal cycle (-55°C to 125°C). The assumption is that conditions that highly stress the solder joints by maximizing the CTE difference between the PWB and the component will favor SnPb over SAC. Conversely, conditions that minimize the stress put on the solder joints (e.g., compliant components such as BGA's and/or a less aggressive thermal cycle) will favor SAC over SnPb.

In support of this assumption, J.P. Clech analyzed the available literature data and was able to demonstrate that with shear strains of greater than 6.2%, SnPb is more reliable than SAC while the reverse is true with lesser shear strains (Reference 5).

Bartello (Reference 6) was able to show that the thermal cycle and dwell time used for conducting accelerated thermal cycling can greatly affect the results of the test. He examined the effects of temperatures and dwell times on the relative survival times of ceramic BGA's with SnPb or SAC solder joints. Bartello found that aggressive thermal cycles with long dwell times favor SnPb over SAC. SAC alloys are resistant to creep and it is believed that these test conditions force the SAC alloy to creep more which results in more damage accumulation per cycle.

The question remains “Which thermal cycle/dwell time combination will give test results that best predict the behavior of solders under field conditions?” The best answer is that models need to be developed (and verified with actual thermal cycle test data) which can be used to accurately predict field lifetimes for lead-free solders used with different component types. A verified model will allow any thermal cycle data to be extrapolated to field lifetimes.

5.0 Conclusions and Recommendations

Most of the components exposed to 1000 cycles of -55°C to 125°C thermal shock (15 minute dwells) did not fail. The ceramic leadless chip carriers (CLCC's) did have a large percentage of failures, however. Based solely on the data from the CLCC failures, SnPb is more reliable than SnAgCuBi which in turn is more reliable than SnAgCu (Figure 30).

This result does not necessarily mean that lead-free solders should be restricted from use in high reliability electronics, but it does imply that models for calculating the actual field lifetime of lead-free solder joints will need to be developed in order to verify that lead-free solders will survive for the required lifetime of a given circuit assembly design.

Contamination of the lead-free CLCC solder joints with large amounts of lead (17%) only resulted in a modest decrease in the reliability of the lead-free solders (SnAgCu and SnAgCuBi, Figure 31). Pb-contamination was expected to have a large negative effect on the reliability of SnAgCuBi due to the formation of the low melting ternary 16Sn32Pb52Bi alloy. It is not understood why it did not.

In contrast, contamination of lead-free TSOP solder joints with small amounts of lead (3%) resulted in a large decrease in the reliability of SnAgCuBi (Figure 32). This negative effect of small amounts of lead on the reliability of bismuth-containing solders has been previously observed (Reference 4). To ensure maximum reliability, SnAgCuBi solder should not be used when there is a chance that it may be mixed with SnPb solder.

SnPb solder used in combination with SnAgCu or SnAgCuBi component finishes grossly underperformed the combination of SnPb solder with a SnPb finish (Figures 33 and 35). Since a SnPb reflow profile was used, mixing of the SnPb solder and the lead-free finishes was expected to be minimal but ICP analysis suggested that solder mixing did occur. To ensure maximum reliability, SnPb solders should not be used with SnAgCu or SnAgCuBi component finishes (e.g., SnAgCu BGA balls).

SnPb balls assembled with SAC paste failed on six out of a total of 25 BGA's (see Table 8). This suggests that using SnPb BGA's in combination with SAC solder is to be avoided. In comparison, only one failure was seen when SACB paste was used with SnPb balls.

No BGA failures were observed for the combinations of SnPb paste/SnPb balls; SAC paste/SAC balls; or SACB paste/ SAC balls.

Rework did have a negative effect on some components. During rework, the old component was removed; the pads were wicked clean of most but not all of the SnPb; and a new component was attached using a lead-free solder. Therefore, all solder joints on the "Rework" vehicles contain lead, even the components that were reworked (see Table 5). The effects of lead contamination and the effects (if any) of the heat of the rework operation upon the reliability of the solder joints in this test are not readily separable from each other.

Figure 34 demonstrates that the TSOP's reworked with SnAgCuBi had a greatly reduced reliability compared to the SnPb control (not reworked). This could be due to the formation of the 16Sn32Pb52Bi alloy. Surprisingly, the TSOP's reworked with SnPb also show reduced reliability compared to the SnPb control (not reworked). Since Pb contamination can not be blamed, this effect must be due to the heat of the rework operation alone. The TSOP's reworked with SnAgCu were as reliable as the SnPb control (not reworked).

TQFP U3 exhibited numerous failures when reworked with SnAgCu or SnAgCuBi but not with SnPb (Figure 36). The supposedly identical TQFP U57 did not exhibit any failures. TQFP U3 and the adjacent BGA's (U4 and U18) were removed at the same time during rework. It is believed that heat from the replacement of the BGA's prior to replacement of TQFP U3 affected the U3 pads resulting in weak pad/solder interfaces. Microsections need to be done to help clarify the failure mechanisms.

In general, it appears that rework operations have the potential to reduce the reliability of both Pb-free and SnPb solders with no clear trend emerging from the thermal shock data. The results of the JCAA/JG-PP Thermal Cycling Tests may better reveal trends due to rework since more failures will be generated.

6.0 References

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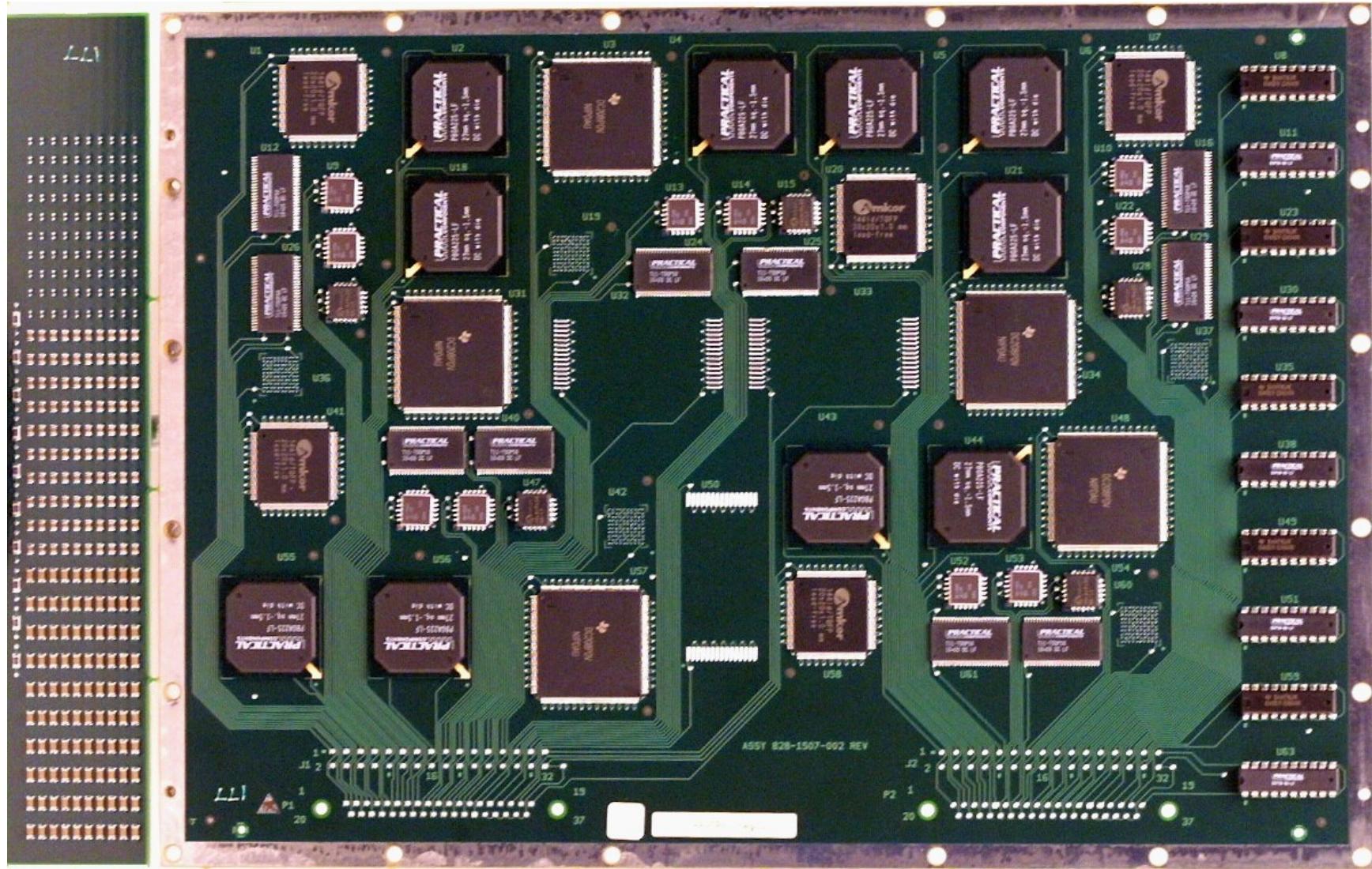


Figure 1. Test Vehicle with Break-Off Coupon Attached

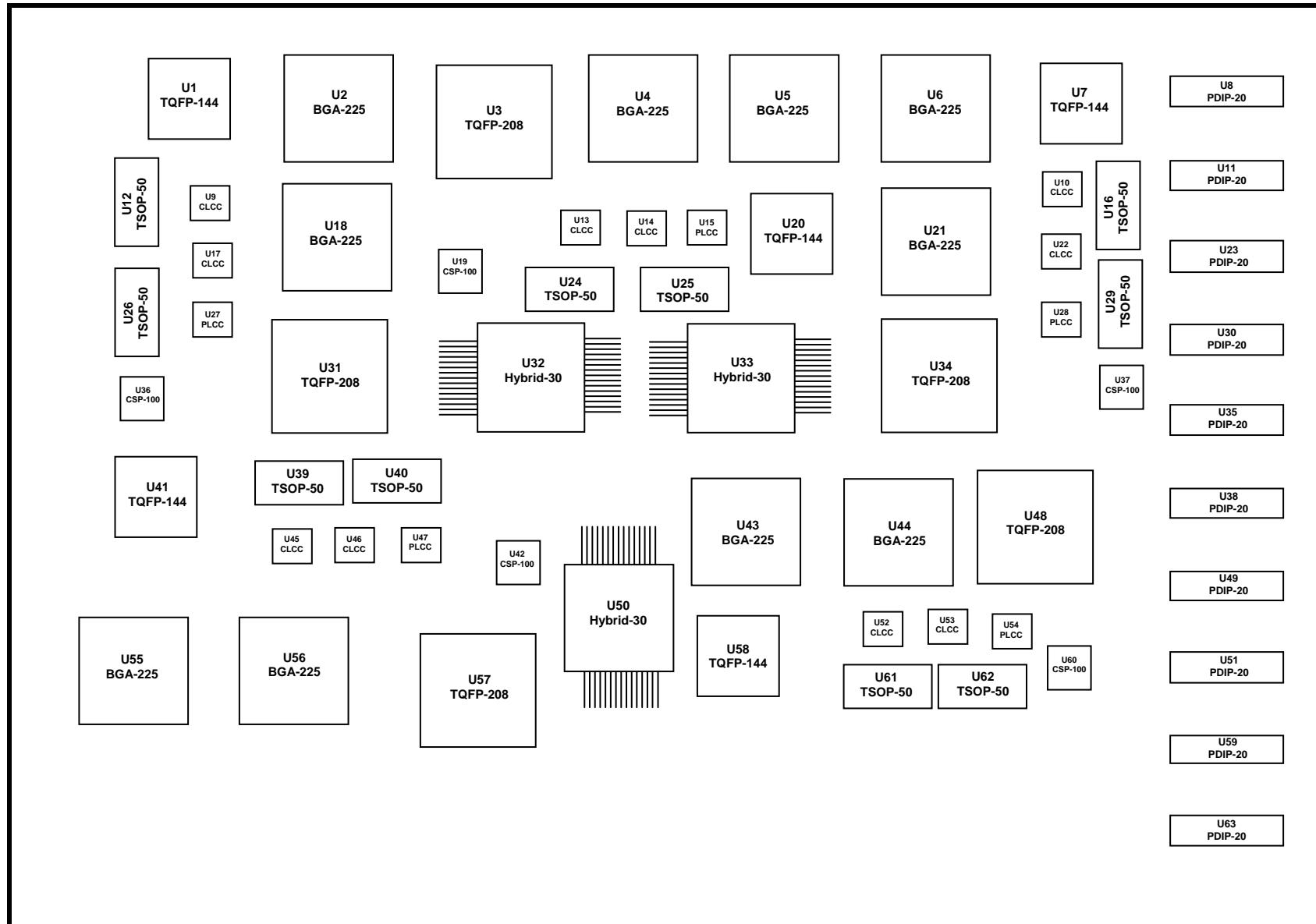


Figure 2. Main Test Vehicle Schematic

Table 1. Test Vehicle Key (“Manufactured” PWA’s – Controls)

Test Vehicle ID Numbers: 1, 10-12, 14

Reference Designator	Component	Component Finish	Reflow Solder Alloy	Wave Solder Alloy (DIP's only)
U1	TQFP-144	Sn	SnPb	
U2	BGA-225	SnPb	SnPb	
U3	TQFP-208	NiPdAu	SnPb	
U4	BGA-225	SnPb	SnPb	
U5	BGA-225	SnPb	SnPb	
U6	BGA-225	SnPb	SnPb	
U7	TQFP-144	Sn	SnPb	
U8	PDIP-20	NiPdAu		SnPb
U9	CLCC-20	SnPb	SnPb	
U10	CLCC-20	SnPb	SnPb	
U11	PDIP-20	Sn		SnPb
U12	TSOP-50	SnPb	SnPb	
U13	CLCC-20	SnPb	SnPb	
U14	CLCC-20	SnPb	SnPb	
U15	PLCC-20	Sn	SnPb	
U16	TSOP-50	SnPb	SnPb	
U17	CLCC-20	SnPb	SnPb	
U18	BGA-225	SnPb	SnPb	
U19	CSP-100	SnPb	SnPb	
U20	TQFP-144	Sn	SnPb	
U21	BGA-225	SnPb	SnPb	
U22	CLCC-20	SnPb	SnPb	
U23	PDIP-20	NiPdAu		SnPb
U24	TSOP-50	SnPb	SnPb	
U25	TSOP-50	SnPb	SnPb	
U26	TSOP-50	SnPb	SnPb	
U27	PLCC-20	Sn	SnPb	
U28	PLCC-20	Sn	SnPb	
U29	TSOP-50	SnPb	SnPb	
U30	PDIP-20	Sn		SnPb
U31	TQFP-208	NiPdAu	SnPb	
U32	Hybrid-30	SnPb	SnPb	
U33	Hybrid-30	SnPb	SnPb	
U34	TQFP-208	NiPdAu	SnPb	
U35	PDIP-20	NiPdAu		SnPb
U36	CSP-100	SnPb	SnPb	
U37	CSP-100	SnPb	SnPb	
U38	PDIP-20	Sn		SnPb
U39	TSOP-50	SnPb	SnPb	
U40	TSOP-50	SnPb	SnPb	
U41	TQFP-144	Sn	SnPb	
U42	CSP-100	SnPb	SnPb	
U43	BGA-225	SnPb	SnPb	
U44	BGA-225	SnPb	SnPb	
U45	CLCC-20	SnPb	SnPb	
U46	CLCC-20	SnPb	SnPb	
U47	PLCC-20	Sn	SnPb	
U48	TQFP-208	NiPdAu	SnPb	
U49	PDIP-20	NiPdAu		SnPb
U50	Hybrid-30	SnPb	SnPb	
U51	PDIP-20	Sn		SnPb
U52	CLCC-20	SnPb	SnPb	
U53	CLCC-20	SnPb	SnPb	
U54	PLCC-20	Sn	SnPb	
U55	BGA-225	SnPb	SnPb	
U56	BGA-225	SnPb	SnPb	
U57	TQFP-208	NiPdAu	SnPb	
U58	TQFP-144	Sn	SnPb	
U59	PDIP-20	NiPdAu		SnPb
U60	CSP-100	SnPb	SnPb	
U61	TSOP-50	SnPb	SnPb	
U62	TSOP-50	SnPb	SnPb	
U63	PDIP-20	Sn		SnPb
Break-Off Coupons				
R1	Chip Resistor	Sn	SnPb	
R2	Chip Resistor	Sn	SnPb	
R3	Chip Resistor	Sn	SnPb	
R4	Chip Resistor	Sn	SnPb	
R5	Chip Resistor	Sn	SnPb	
R6	Chip Resistor	Sn	SnPb	
R7	Chip Resistor	Sn	SnPb	
R8	Chip Resistor	Sn	SnPb	
R9	Chip Resistor	Sn	SnPb	
R10	Chip Resistor	Sn	SnPb	
	Chip Capacitors	Sn	SnPb	

Hybrids and CSPs were left off of the test vehicles.

Table 2. Test Vehicle Key (“Manufactured” PWA’s)

		Test Vehicle ID Numbers: 80 through 84			Test Vehicle ID Numbers: 119 through 123		
Reference Designator	Component	Component Finish	Reflow Solder Alloy	Wave Solder Alloy (DIP's only)	Component Finish	Reflow Solder Alloy	Wave Solder Alloy (DIP's only)
U1	TQFP-144	Sn	Sn3.9Ag0.6Cu		Sn	Sn3.4Ag1Cu3.3Bi	
U2	BGA-225	SnPb	Sn3.9Ag0.6Cu		SnPb	Sn3.4Ag1Cu3.3Bi	
U3	TQFP-208	NiPdAu	Sn3.9Ag0.6Cu		NiPdAu	Sn3.4Ag1Cu3.3Bi	
U4	BGA-225	SnAgCu	Sn3.9Ag0.6Cu		SnAgCu	Sn3.4Ag1Cu3.3Bi	
U5	BGA-225	SnPb	Sn3.9Ag0.6Cu		SnPb	Sn3.4Ag1Cu3.3Bi	
U6	BGA-225	SnAgCu	Sn3.9Ag0.6Cu		SnAgCu	Sn3.4Ag1Cu3.3Bi	
U7	TQFP-144	Sn	Sn3.9Ag0.6Cu		Sn	Sn3.4Ag1Cu3.3Bi	
U8	PDIP-20	NiPdAu		Sn3.9Ag0.6Cu	NiPdAu		Sn0.7Cu0.05Ni
U9	CLCC-20	SnPb	Sn3.9Ag0.6Cu		SnPb	Sn3.4Ag1Cu3.3Bi	
U10	CLCC-20	Sn3.9Ag0.6Cu	Sn3.9Ag0.6Cu		Sn3.4Ag1Cu3.3Bi	Sn3.4Ag1Cu3.3Bi	
U11	PDIP-20	Sn		Sn3.9Ag0.6Cu	Sn		Sn0.7Cu0.05Ni
U12	TSOP-50	SnCu	Sn3.9Ag0.6Cu		SnCu	Sn3.4Ag1Cu3.3Bi	
U13	CLCC-20	SnPb	Sn3.9Ag0.6Cu		SnPb	Sn3.4Ag1Cu3.3Bi	
U14	CLCC-20	Sn3.9Ag0.6Cu	Sn3.9Ag0.6Cu		Sn3.4Ag1Cu3.3Bi	Sn3.4Ag1Cu3.3Bi	
U15	PLCC-20	Sn	Sn3.9Ag0.6Cu		Sn	Sn3.4Ag1Cu3.3Bi	
U16	TSOP-50	SnPb	Sn3.9Ag0.6Cu		SnPb	Sn3.4Ag1Cu3.3Bi	
U17	CLCC-20	Sn3.9Ag0.6Cu	Sn3.9Ag0.6Cu		Sn3.4Ag1Cu3.3Bi	Sn3.4Ag1Cu3.3Bi	
U18	BGA-225	SnAgCu	Sn3.9Ag0.6Cu		SnAgCu	Sn3.4Ag1Cu3.3Bi	
U19	CSP-100	SnAgCu	Sn3.9Ag0.6Cu		SnAgCu	Sn3.4Ag1Cu3.3Bi	
U20	TQFP-144	Sn	Sn3.9Ag0.6Cu		Sn	Sn3.4Ag1Cu3.3Bi	
U21	BGA-225	SnPb	Sn3.9Ag0.6Cu		SnPb	Sn3.4Ag1Cu3.3Bi	
U22	CLCC-20	SnPb	Sn3.9Ag0.6Cu		SnPb	Sn3.4Ag1Cu3.3Bi	
U23	PDIP-20	NiPdAu		Sn3.9Ag0.6Cu	NiPdAu		Sn0.7Cu0.05Ni
U24	TSOP-50	SnPb	Sn3.9Ag0.6Cu		SnPb	Sn3.4Ag1Cu3.3Bi	
U25	TSOP-50	SnCu	Sn3.9Ag0.6Cu		SnCu	Sn3.4Ag1Cu3.3Bi	
U26	TSOP-50	SnPb	Sn3.9Ag0.6Cu		SnPb	Sn3.4Ag1Cu3.3Bi	
U27	PLCC-20	Sn	Sn3.9Ag0.6Cu		Sn	Sn3.4Ag1Cu3.3Bi	
U28	PLCC-20	Sn	Sn3.9Ag0.6Cu		Sn	Sn3.4Ag1Cu3.3Bi	
U29	TSOP-50	SnCu	Sn3.9Ag0.6Cu		SnCu	Sn3.4Ag1Cu3.3Bi	
U30	PDIP-20	Sn		Sn3.9Ag0.6Cu	Sn		Sn0.7Cu0.05Ni
U31	TQFP-208	NiPdAu	Sn3.9Ag0.6Cu		NiPdAu	Sn3.4Ag1Cu3.3Bi	
U32	Hybrid-30	Sn3.9Ag0.6Cu	Sn3.9Ag0.6Cu		Sn3.4Ag1Cu3.3Bi	Sn3.4Ag1Cu3.3Bi	
U33	Hybrid-30	Sn3.9Ag0.6Cu	Sn3.9Ag0.6Cu		Sn3.4Ag1Cu3.3Bi	Sn3.4Ag1Cu3.3Bi	
U34	TQFP-208	NiPdAu	Sn3.9Ag0.6Cu		NiPdAu	Sn3.4Ag1Cu3.3Bi	
U35	PDIP-20	NiPdAu		Sn3.9Ag0.6Cu	NiPdAu		Sn0.7Cu0.05Ni
U36	CSP-100	SnAgCu	Sn3.9Ag0.6Cu		SnAgCu	Sn3.4Ag1Cu3.3Bi	
U37	CSP-100	SnAgCu	Sn3.9Ag0.6Cu		SnAgCu	Sn3.4Ag1Cu3.3Bi	
U38	PDIP-20	Sn		Sn3.9Ag0.6Cu	Sn		Sn0.7Cu0.05Ni
U39	TSOP-50	SnCu	Sn3.9Ag0.6Cu		SnCu	Sn3.4Ag1Cu3.3Bi	
U40	TSOP-50	SnPb	Sn3.9Ag0.6Cu		SnPb	Sn3.4Ag1Cu3.3Bi	
U41	TQFP-144	Sn	Sn3.9Ag0.6Cu		Sn	Sn3.4Ag1Cu3.3Bi	
U42	CSP-100	SnAgCu	Sn3.9Ag0.6Cu		SnAgCu	Sn3.4Ag1Cu3.3Bi	
U43	BGA-225	SnAgCu	Sn3.9Ag0.6Cu		SnAgCu	Sn3.4Ag1Cu3.3Bi	
U44	BGA-225	SnPb	Sn3.9Ag0.6Cu		SnPb	Sn3.4Ag1Cu3.3Bi	
U45	CLCC-20	Sn3.9Ag0.6Cu	Sn3.9Ag0.6Cu		Sn3.4Ag1Cu3.3Bi	Sn3.4Ag1Cu3.3Bi	
U46	CLCC-20	SnPb	Sn3.9Ag0.6Cu		SnPb	Sn3.4Ag1Cu3.3Bi	
U47	PLCC-20	Sn	Sn3.9Ag0.6Cu		Sn	Sn3.4Ag1Cu3.3Bi	
U48	TQFP-208	NiPdAu	Sn3.9Ag0.6Cu		NiPdAu	Sn3.4Ag1Cu3.3Bi	
U49	PDIP-20	NiPdAu		Sn3.9Ag0.6Cu	NiPdAu		Sn0.7Cu0.05Ni
U50	Hybrid-30	Sn3.9Ag0.6Cu	Sn3.9Ag0.6Cu		Sn3.4Ag1Cu3.3Bi	Sn3.4Ag1Cu3.3Bi	
U51	PDIP-20	Sn		Sn3.9Ag0.6Cu	Sn		Sn0.7Cu0.05Ni
U52	CLCC-20	Sn3.9Ag0.6Cu	Sn3.9Ag0.6Cu		Sn3.4Ag1Cu3.3Bi	Sn3.4Ag1Cu3.3Bi	
U53	CLCC-20	SnPb	Sn3.9Ag0.6Cu		SnPb	Sn3.4Ag1Cu3.3Bi	
U54	PLCC-20	Sn	Sn3.9Ag0.6Cu		Sn	Sn3.4Ag1Cu3.3Bi	
U55	BGA-225	SnAgCu	Sn3.9Ag0.6Cu		SnAgCu	Sn3.4Ag1Cu3.3Bi	
U56	BGA-225	SnPb	Sn3.9Ag0.6Cu		SnPb	Sn3.4Ag1Cu3.3Bi	
U57	TQFP-208	NiPdAu	Sn3.9Ag0.6Cu		NiPdAu	Sn3.4Ag1Cu3.3Bi	
U58	TQFP-144	Sn	Sn3.9Ag0.6Cu		Sn	Sn3.4Ag1Cu3.3Bi	
U59	PDIP-20	NiPdAu		Sn3.9Ag0.6Cu	NiPdAu		Sn0.7Cu0.05Ni
U60	CSP-100	SnAgCu	Sn3.9Ag0.6Cu		SnAgCu	Sn3.4Ag1Cu3.3Bi	
U61	TSOP-50	SnCu	Sn3.9Ag0.6Cu		SnCu	Sn3.4Ag1Cu3.3Bi	
U62	TSOP-50	SnPb	Sn3.9Ag0.6Cu		SnPb	Sn3.4Ag1Cu3.3Bi	
U63	PDIP-20	Sn		Sn3.9Ag0.6Cu	Sn		Sn0.7Cu0.05Ni
Break-Off Coupons							
R1	Chip Resistor	Sn	Sn3.9Ag0.6Cu		Sn	Sn3.4Ag1Cu3.3Bi	
R2	Chip Resistor	Sn	Sn3.9Ag0.6Cu		Sn	Sn3.4Ag1Cu3.3Bi	
R3	Chip Resistor	Sn	Sn3.9Ag0.6Cu		Sn	Sn3.4Ag1Cu3.3Bi	
R4	Chip Resistor	Sn	Sn3.9Ag0.6Cu		Sn	Sn3.4Ag1Cu3.3Bi	
R5	Chip Resistor	Sn	Sn3.9Ag0.6Cu		Sn	Sn3.4Ag1Cu3.3Bi	
R6	Chip Resistor	Sn	Sn3.9Ag0.6Cu		Sn	Sn3.4Ag1Cu3.3Bi	
R7	Chip Resistor	Sn	Sn3.9Ag0.6Cu		Sn	Sn3.4Ag1Cu3.3Bi	
R8	Chip Resistor	Sn	Sn3.9Ag0.6Cu		Sn	Sn3.4Ag1Cu3.3Bi	
R9	Chip Resistor	Sn	Sn3.9Ag0.6Cu		Sn	Sn3.4Ag1Cu3.3Bi	
R10	Chip Capacitors	Sn	Sn3.9Ag0.6Cu		Sn	Sn3.4Ag1Cu3.3Bi	

Hybrids and CSPs were left off of the test vehicles.
SnAgCu BGA balls were Sn4.0Ag0.5Cu.

Table 3. Test Vehicle Key (“Rework” PWA’s – Controls)

Test Vehicle ID Numbers: 51 through 55

Reference Designator	Component	Component Finish (Before Rework)	Reflow Solder Alloy (Before Rework)	Wave Solder Alloy (Before Rework)	Component Finish (After Rework)	Rework Solder Alloy
U1	TQFP-144	Sn	SnPb			
U2	BGA-225	SnPb	SnPb			
U3	TQFP-208	NiPdAu	SnPb		NiPdAu	SnPb
U4	BGA-225	SnPb	SnPb		SnPb	SnPb
U5	BGA-225	SnPb	SnPb			
U6	BGA-225	SnPb	SnPb			
U7	TQFP-144	Sn	SnPb			
U8	PDIP-20	NiPdAu		SnPb		
U9	CLCC-20	SnPb	SnPb			
U10	CLCC-20	SnPb	SnPb			
U11	PDIP-20	Sn		SnPb		
U12	TSOP-50	SnPb	SnPb		SnPb	SnPb
U13	CLCC-20	SnPb	SnPb			
U14	CLCC-20	SnPb	SnPb			
U15	PLCC-20	Sn	SnPb			
U16	TSOP-50	SnPb	SnPb			
U17	CLCC-20	SnPb	SnPb			
U18	BGA-225	SnPb	SnPb		SnPb	SnPb
U19	CSP-100	SnPb	SnPb			
U20	TQFP-144	Sn	SnPb			
U21	BGA-225	SnPb	SnPb			
U22	CLCC-20	SnPb	SnPb			
U23	PDIP-20	NiPdAu		SnPb	NiPdAu	SnPb
U24	TSOP-50	SnPb	SnPb			
U25	TSOP-50	SnPb	SnPb		SnPb	SnPb
U26	TSOP-50	SnPb	SnPb			
U27	PLCC-20	Sn	SnPb			
U28	PLCC-20	Sn	SnPb			
U29	TSOP-50	SnPb	SnPb			
U30	PDIP-20	Sn		SnPb		
U31	TQFP-208	NiPdAu	SnPb			
U32	Hybrid-30	SnPb	SnPb			
U33	Hybrid-30	SnPb	SnPb			
U34	TQFP-208	NiPdAu	SnPb			
U35	PDIP-20	NiPdAu		SnPb		
U36	CSP-100	SnPb	SnPb			
U37	CSP-100	SnPb	SnPb			
U38	PDIP-20	Sn		SnPb		
U39	TSOP-50	SnPb	SnPb			
U40	TSOP-50	SnPb	SnPb			
U41	TQFP-144	Sn	SnPb			
U42	CSP-100	SnPb	SnPb			
U43	BGA-225	SnPb	SnPb			
U44	BGA-225	SnPb	SnPb			
U45	CLCC-20	SnPb	SnPb			
U46	CLCC-20	SnPb	SnPb			
U47	PLCC-20	Sn	SnPb			
U48	TQFP-208	NiPdAu	SnPb			
U49	PDIP-20	NiPdAu		SnPb		
U50	Hybrid-30	SnPb	SnPb			
U51	PDIP-20	Sn		SnPb		
U52	CLCC-20	SnPb	SnPb			
U53	CLCC-20	SnPb	SnPb			
U54	PLCC-20	Sn	SnPb			
U55	BGA-225	SnPb	SnPb			
U56	BGA-225	SnPb	SnPb			
U57	TQFP-208	NiPdAu	SnPb		NiPdAu	SnPb
U58	TQFP-144	Sn	SnPb			
U59	PDIP-20	NiPdAu		SnPb	NiPdAu	SnPb
U60	CSP-100	SnPb	SnPb			
U61	TSOP-50	SnPb	SnPb			
U62	TSOP-50	SnPb	SnPb			
U63	PDIP-20	Sn		SnPb		

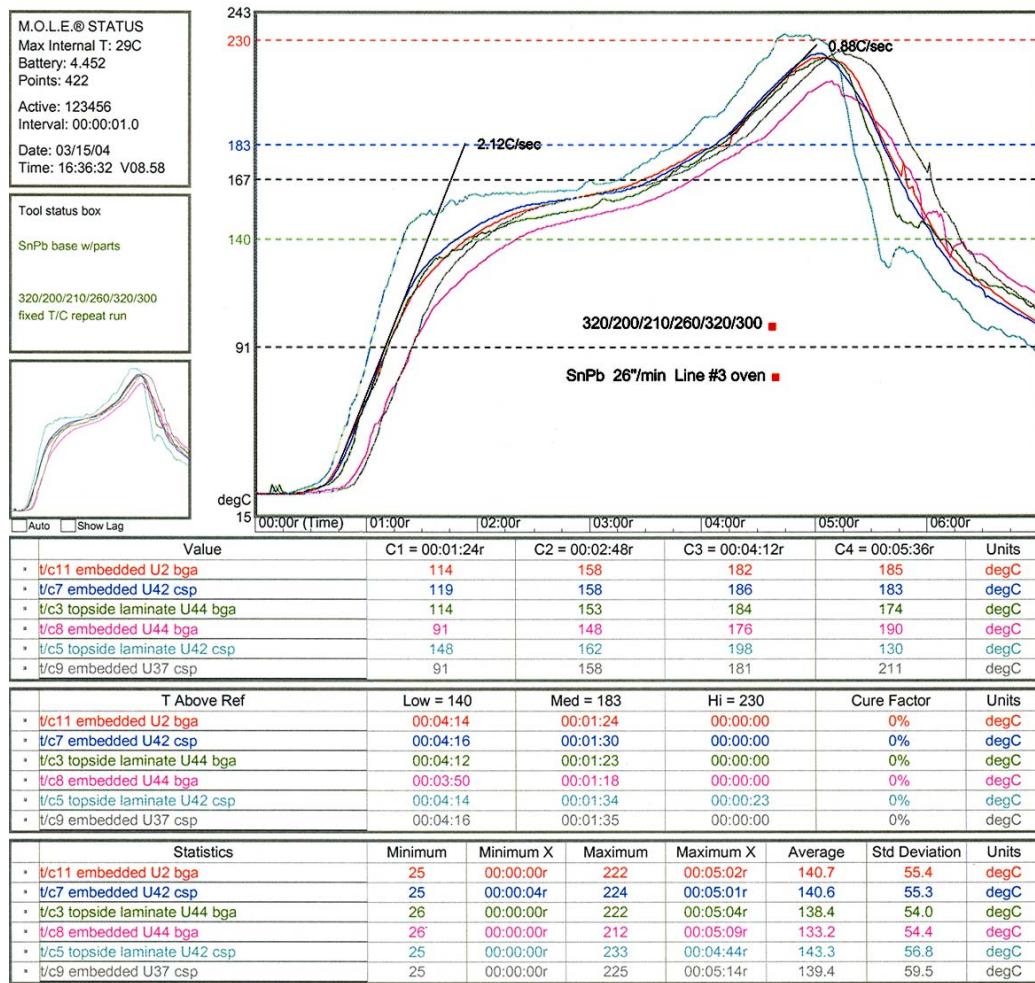
Reworked components are shown in red.

Hybrids and CSPs were left off of the test vehicles.

Table 4. Test Vehicle Key (“Rework” PWA’s)

Reference Designator	Component	Reflow Solder Alloy (Before Rework)	Wave Solder Alloy (Before Rework)	Test Vehicle ID Numbers: 158 through 162			Test Vehicle ID Numbers: 186 through 190		
				Component Finish (Before Rework)	Component Finish (After Rework)	Rework Solder Alloy	Component Finish (Before Rework)	Component Finish (After Rework)	Rework Solder Alloy
U1	TQFP-144	SnPb		Sn			Sn		
U2	BGA-225	SnPb		SnAgCu			SnAgCu		
U3	TQFP-208	SnPb		NiPdAu	NiPdAu	Sn3.9Ag0.6Cu	NiPdAu	NiPdAu	Sn3.4Ag1Cu3.3Bi
U4	BGA-225	SnPb		SnPb	SnAgCu	flux only	SnPb	SnAgCu	flux only
U5	BGA-225	SnPb		SnAgCu			SnAgCu		
U6	BGA-225	SnPb		SnAgCu			SnAgCu		
U7	TQFP-144	SnPb		Sn			Sn		
U8	PDIP-20		SnPb	NiPdAu			NiPdAu		
U9	CLCC-20	SnPb		Sn3.9Ag0.6Cu			Sn3.4Ag1Cu3.3Bi		
U10	CLCC-20	SnPb		Sn3.9Ag0.6Cu			Sn3.4Ag1Cu3.3Bi		
U11	PDIP-20		SnPb	Sn			Sn		
U12	TSOP-50	SnPb		SnPb	SnCu	Sn3.9Ag0.6Cu	SnPb	SnCu	Sn3.4Ag1Cu3.3Bi
U13	CLCC-20	SnPb		Sn3.9Ag0.6Cu			Sn3.4Ag1Cu3.3Bi		
U14	CLCC-20	SnPb		Sn3.9Ag0.6Cu			Sn3.4Ag1Cu3.3Bi		
U15	PLCC-20	SnPb		Sn			Sn		
U16	TSOP-50	SnPb		SnCu			SnCu		
U17	CLCC-20	SnPb		Sn3.9Ag0.6Cu			Sn3.4Ag1Cu3.3Bi		
U18	BGA-225	SnPb		SnPb	SnAgCu	flux only	SnPb	SnAgCu	flux only
U19	CSP-100	SnPb		SnAgCu			SnAgCu		
U20	TQFP-144	SnPb		Sn			Sn		
U21	BGA-225	SnPb		SnAgCu			SnAgCu		
U22	CLCC-20	SnPb		Sn3.9Ag0.6Cu			Sn3.4Ag1Cu3.3Bi		
U23	PDIP-20		SnPb	NiPdAu	NiPdAu	Sn3.9Ag0.6Cu	NiPdAu	NiPdAu	Sn0.7Cu0.05Ni
U24	TSOP-50	SnPb		SnCu			SnCu		
U25	TSOP-50	SnPb		SnPb	SnCu	Sn3.9Ag0.6Cu	SnPb	SnCu	Sn3.4Ag1Cu3.3Bi
U26	TSOP-50	SnPb		SnCu			SnCu		
U27	PLCC-20	SnPb		Sn			Sn		
U28	PLCC-20	SnPb		Sn			Sn		
U29	TSOP-50	SnPb		SnCu			SnCu		
U30	PDIP-20		SnPb	Sn			Sn		
U31	TQFP-208	SnPb		NiPdAu			NiPdAu		
U32	Hybrid-30	SnPb		Sn3.9Ag0.6Cu			Sn3.4Ag1Cu3.3Bi		
U33	Hybrid-30	SnPb		Sn3.9Ag0.6Cu			Sn3.4Ag1Cu3.3Bi		
U34	TQFP-208	SnPb		NiPdAu			NiPdAu		
U35	PDIP-20		SnPb	NiPdAu			NiPdAu		
U36	CSP-100	SnPb		SnAgCu			SnAgCu		
U37	CSP-100	SnPb		SnAgCu			SnAgCu		
U38	PDIP-20		SnPb	Sn			Sn		
U39	TSOP-50	SnPb		SnCu			SnCu		
U40	TSOP-50	SnPb		SnCu			SnCu		
U41	TQFP-144	SnPb		Sn			Sn		
U42	CSP-100	SnPb		SnAgCu			SnAgCu		
U43	BGA-225	SnPb		SnAgCu			SnAgCu		
U44	BGA-225	SnPb		SnAgCu			SnAgCu		
U45	CLCC-20	SnPb		Sn3.9Ag0.6Cu			Sn3.4Ag1Cu3.3Bi		
U46	CLCC-20	SnPb		Sn3.9Ag0.6Cu			Sn3.4Ag1Cu3.3Bi		
U47	PLCC-20	SnPb		Sn			Sn		
U48	TQFP-208	SnPb		NiPdAu			NiPdAu		
U49	PDIP-20		SnPb	NiPdAu			NiPdAu		
U50	Hybrid-30	SnPb		Sn3.9Ag0.6Cu			Sn3.4Ag1Cu3.3Bi		
U51	PDIP-20		SnPb	Sn			Sn		
U52	CLCC-20	SnPb		Sn3.9Ag0.6Cu			Sn3.4Ag1Cu3.3Bi		
U53	CLCC-20	SnPb		Sn3.9Ag0.6Cu			Sn3.4Ag1Cu3.3Bi		
U54	PLCC-20	SnPb		Sn			Sn		
U55	BGA-225	SnPb		SnAgCu			SnAgCu		
U56	BGA-225	SnPb		SnAgCu			SnAgCu		
U57	TQFP-208	SnPb		NiPdAu	NiPdAu	Sn3.9Ag0.6Cu	NiPdAu	NiPdAu	Sn3.4Ag1Cu3.3Bi
U58	TQFP-144	SnPb		Sn			Sn		
U59	PDIP-20		SnPb	NiPdAu	NiPdAu	Sn3.9Ag0.6Cu	NiPdAu	NiPdAu	Sn0.7Cu0.05Ni
U60	CSP-100	SnPb		SnAgCu			SnAgCu		
U61	TSOP-50	SnPb		SnCu			SnCu		
U62	TSOP-50	SnPb		SnCu			SnCu		
U63	PDIP-20		SnPb	Sn			Sn		

Reworked components are shown in red. Hybrids and CSPs were left off of the test vehicles. SnAgCu BGA balls were Sn4.0Ag0.5Cu.



Preheat = ~ 120 seconds @ 140-183°C

Peak temperature target = 225°C
Reflow target:
60-90 sec above 183°C
Ramp Rate = 2-3 °C/sec

Figure 3. Reflow Profile for SnPb Solder Paste

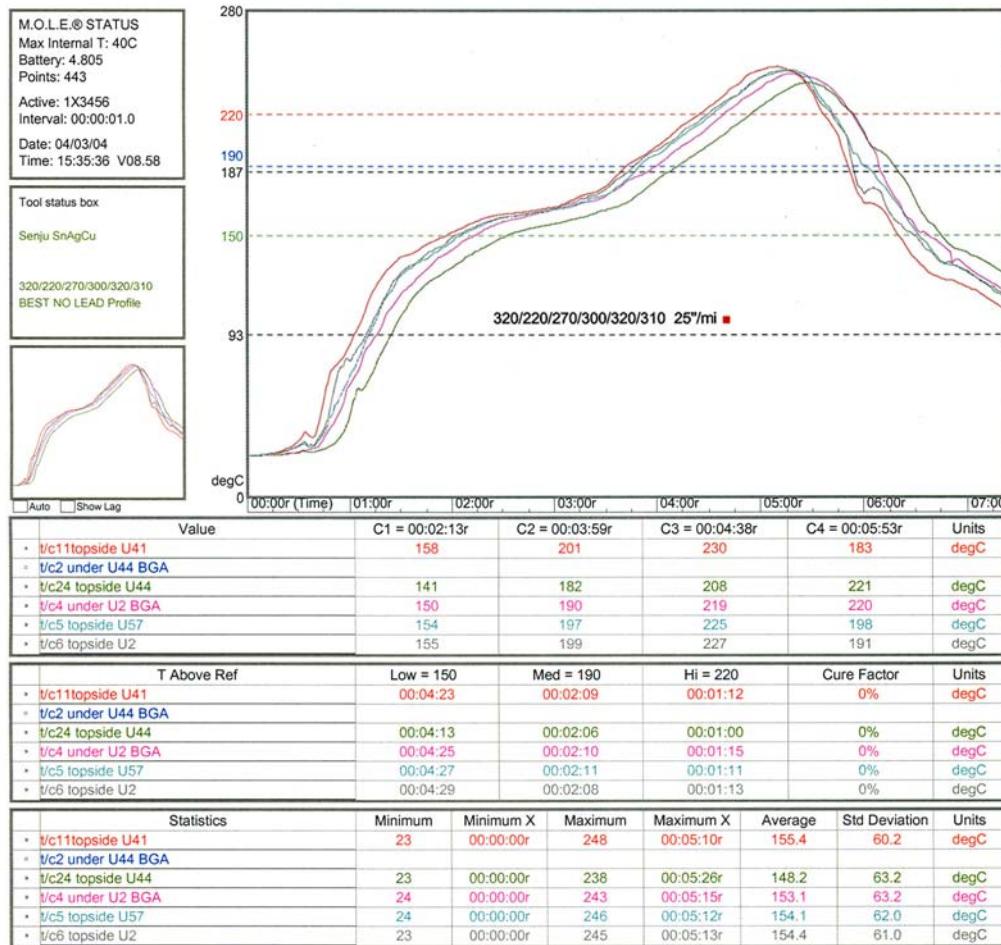
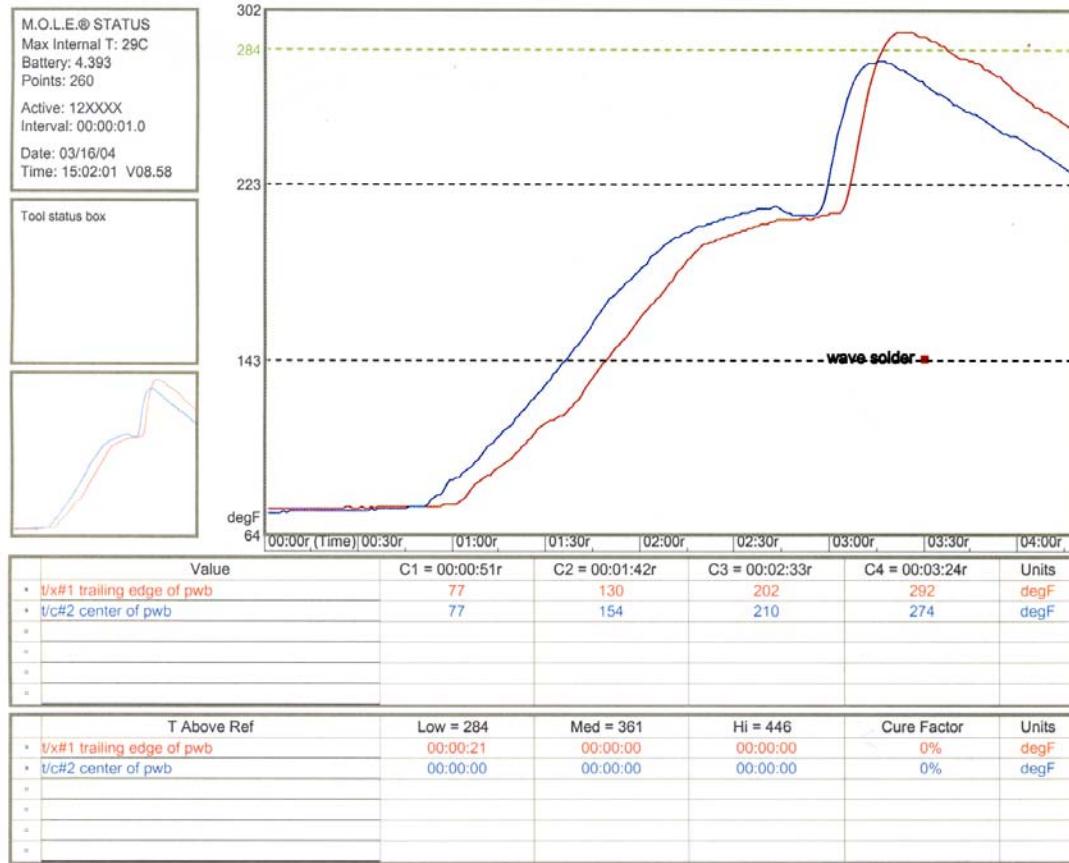
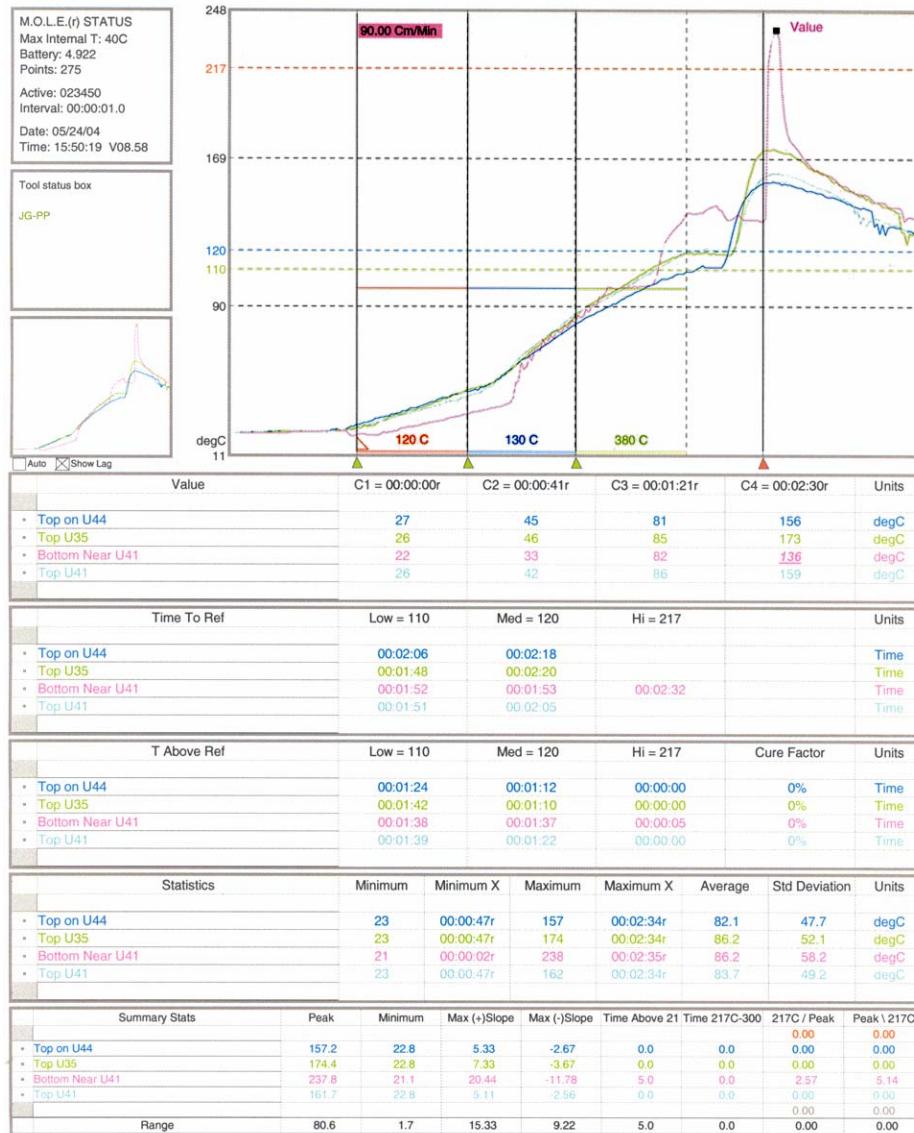


Figure 4. Reflow Profile for SnAgCu and SnAgCuBi Solder Pastes



Solder Pot Temperature = 250°C
Peak Board Temp. (Top) = 144°C
Conveyor Speed: 110 cm/min

Figure 5. Wave Soldering Profile for SnPb Solder



For SnCu:

Solder Pot Temperature = 265°C
Peak Board Temp. (Top) = 157°C
Conveyor Speed: 90 cm/min

For SnAgCu:

Solder Pot Temperature = 260°C
Peak Board Temp. (Top) = 161°C
Conveyor Speed: 90 cm/min

Figure 6. Wave Soldering Profile for SnCu and SnAgCu Solders

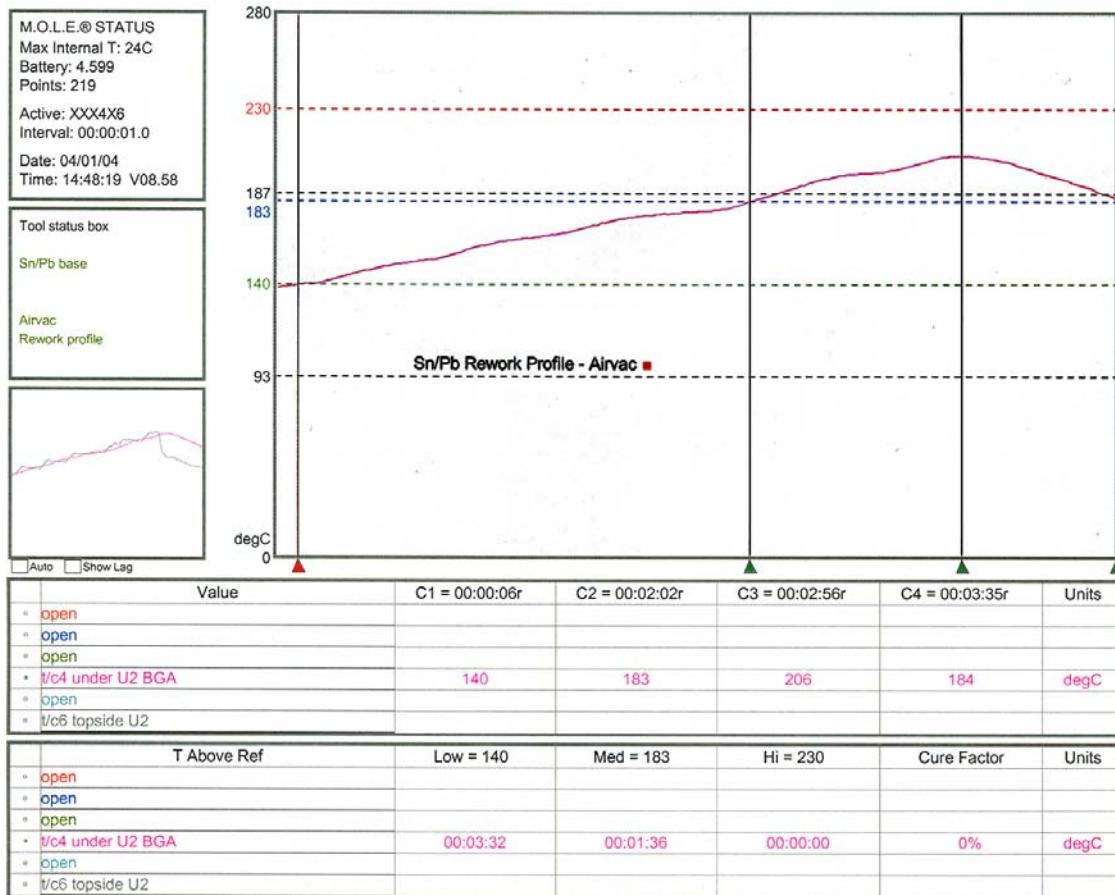
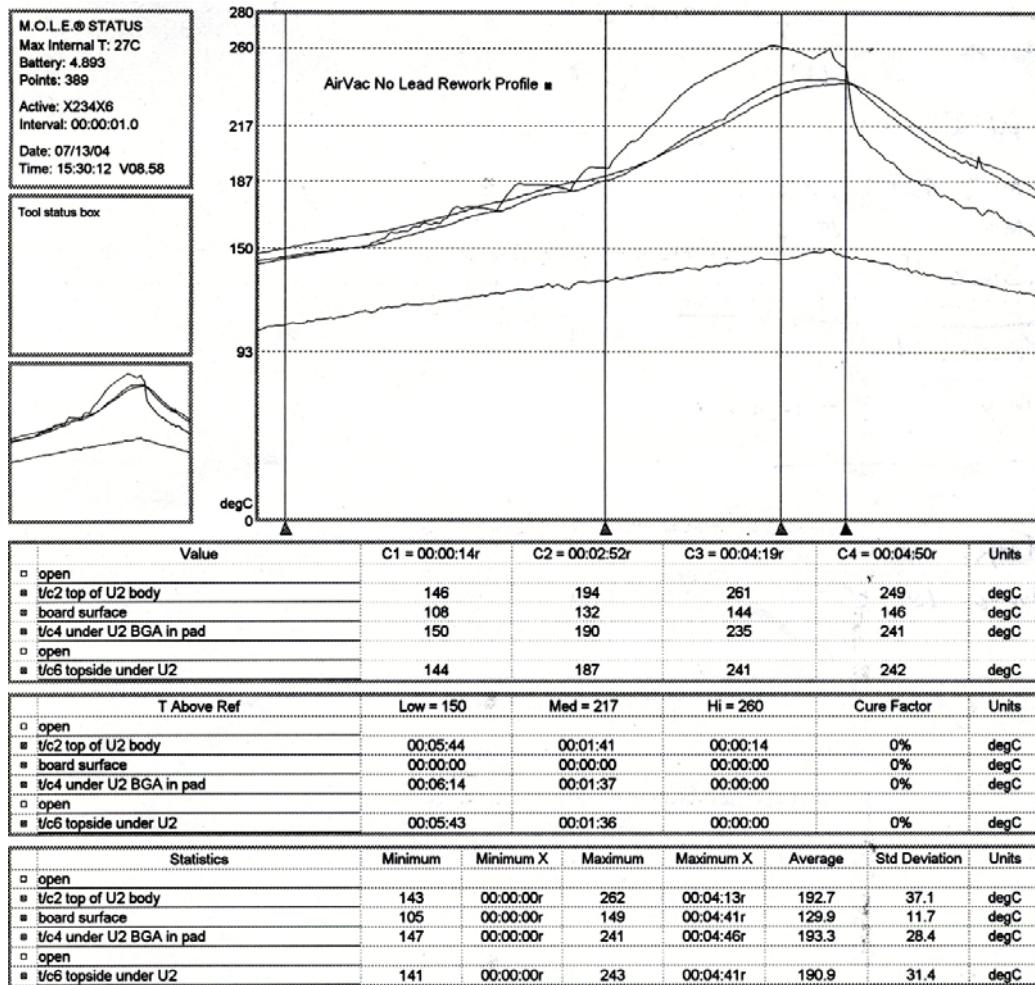


Figure 7. Air-Vac Rework Profile for SnPb Solder (BGA Removal and Replacement)



BGA ball target temp. = 243°C
 BGA top max target temp. = 260°C
 Board max temp. = 150°C
 Reflow targets:
 ~97 seconds above 217°C
 ~75 seconds above 221°C
 ~44 seconds above 235°C
 Ramp rate 1.14°C/sec

Figure 8. Air-Vac Rework Profile for Lead-Free Solders (BGA Removal and Replacement)

Table 5. Chemical Analysis of Solder Joints Contaminated with Pb (by ICP Spectroscopy)

Component	Ref. Des.	Test Vehicle ID	Reworked?	Component Finish	Board Finish	Solder	%Ag	%Cu	%Pb	%Sn	%Bi	%Au
CLCC	U9	80	no	SnPb	Ag	Sn3.9Ag0.6Cu	2.50	0.72	16.48	80.04	0.05	0.21
CLCC	U9	119	no	SnPb	Ag	Sn3.4Ag1.0Cu3.3Bi	2.23	0.82	16.76	78.07	1.94	0.18
CLCC	U9	158	no	Sn3.9Ag0.6Cu	SnPb	SnPb	1.52	0.62	22.72	75.11	0	0.03
CLCC	U9	186	no	Sn3.4Ag1.0Cu3.3Bi	SnPb	SnPb	1.32	0.57	22.93	73.86	1.30	0.02
TSOP	U26	80	no	SnPb	Ag	Sn3.9Ag0.6Cu	3.67	1.12	2.84	92.36	0.01	0
TSOP	U26	119	no	SnPb	Ag	Sn3.4Ag1.0Cu3.3Bi	3.16	1.98	3.05	89.01	2.80	0
TSOP	U12	158	yes	SnCu	Residual SnPb	Sn3.9Ag0.6Cu	3.31	2.12	0.86	93.71	0	0
TSOP	U12	186	yes	SnCu	Residual SnPb	Sn3.4Ag1.0Cu3.3Bi	2.89	1.98	1.06	91.52	2.55	0
BGA	U55	158	no	Sn4.0Ag0.5Cu	SnPb	SnPb	3.42	0.70	4.37	91.33	0	0.18
BGA	U4	158	yes	Sn4.0Ag0.5Cu	Residual SnPb	Flux Only	3.86	0.88	0.31	94.69	0	0.26
BGA	U4	186	yes	Sn4.0Ag0.5Cu	Residual SnPb	Flux Only	3.81	0.99	0.30	94.66	0	0.24
PDIP	U59	158	yes	NiPdAu	Residual SnPb	Sn3.9Ag0.6Cu	3.50	0.99	2.98	92.53	0	0
PDIP	U59	186	yes	NiPdAu	Residual SnPb	Sn0.7Cu0.05Ni	0	1.04	0.38	98.58	0	0
QFP-208	U3	158	yes	NiPdAu	Residual SnPb	Sn3.9Ag0.6Cu	3.34	6.63*	1.13	88.89	<0.05	<0.05

* Copper may have been removed from pads when solder joints were cut from vehicle

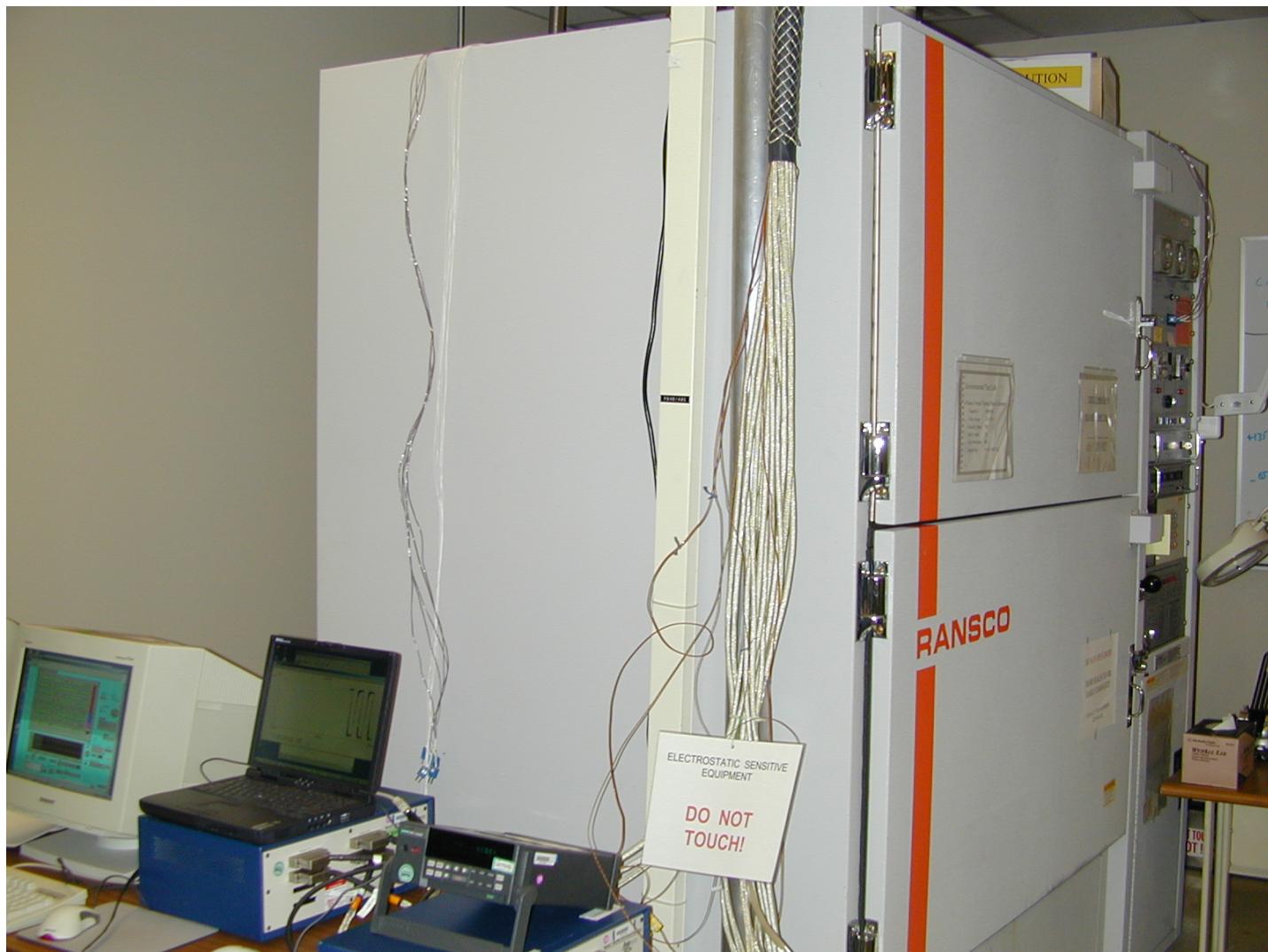


Figure 9. Vertical Thermal Shock Chamber

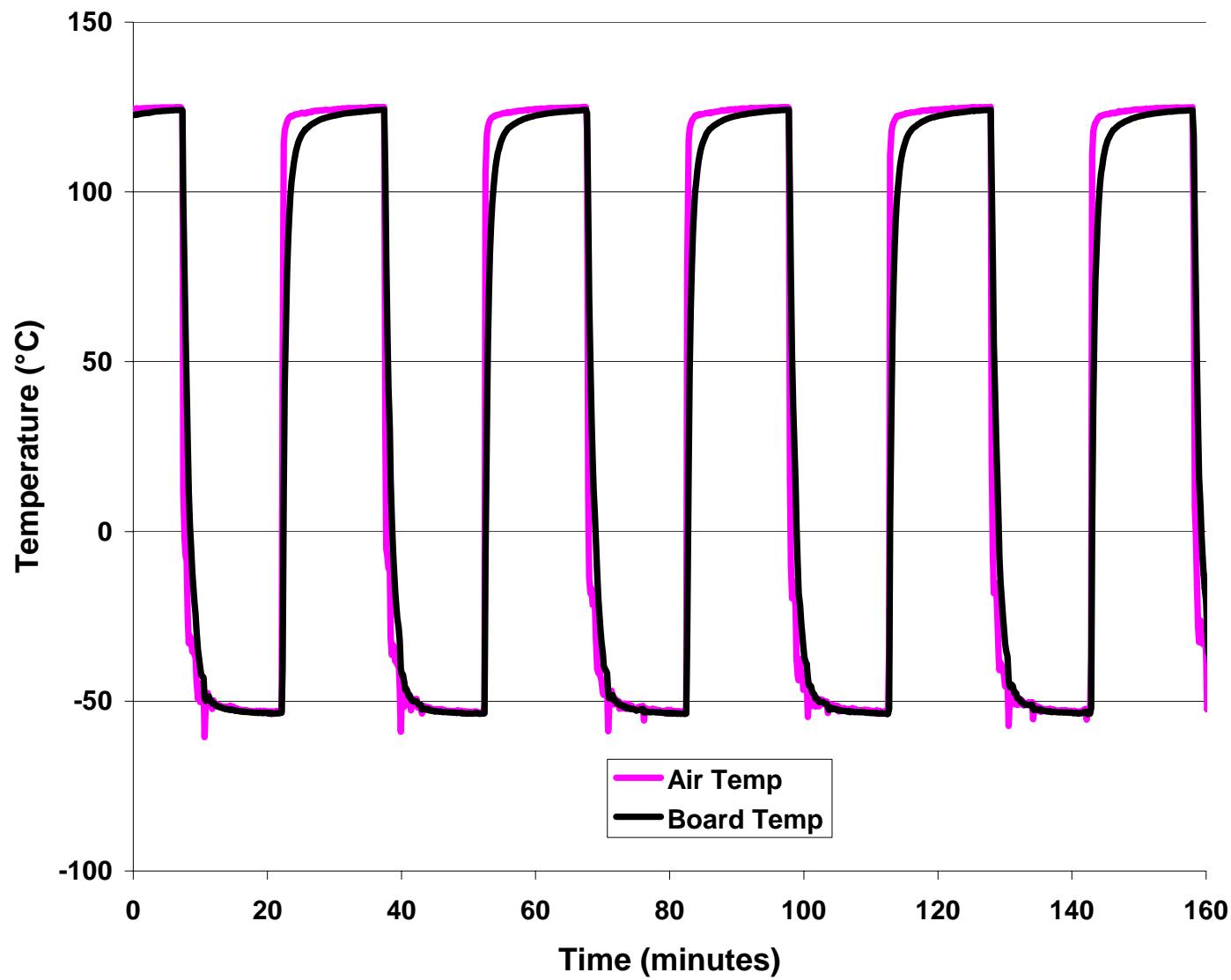


Figure 10. Thermal Shock Cycle (-55°C to 125°C, 15 min. dwells)

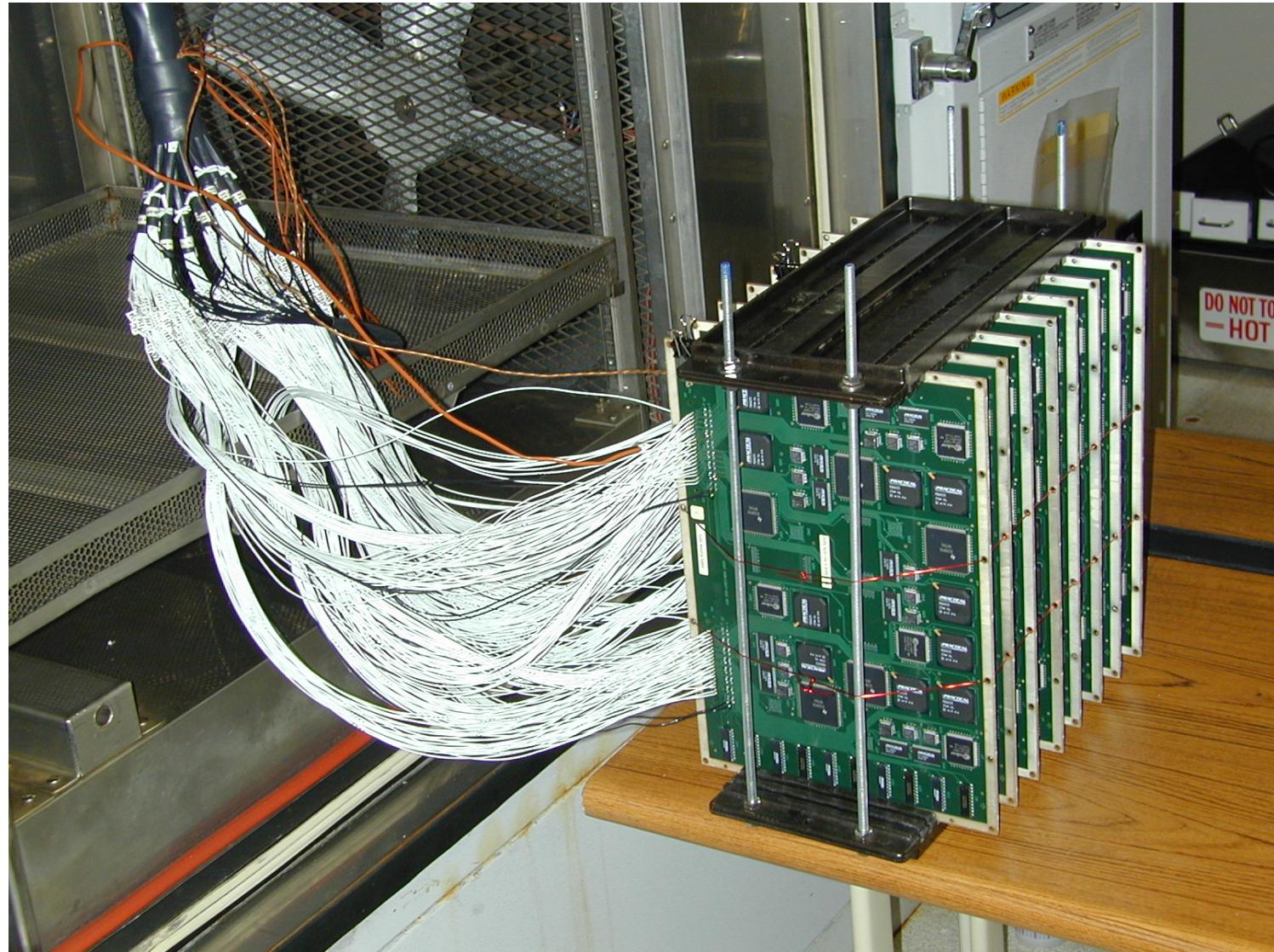


Figure 11. Eight Test Vehicles Ready for Insertion into the Chamber



Figure 12. Vehicle ID 1, CLCC U13, SnPb Solder/SnPb Component Finish, 75x

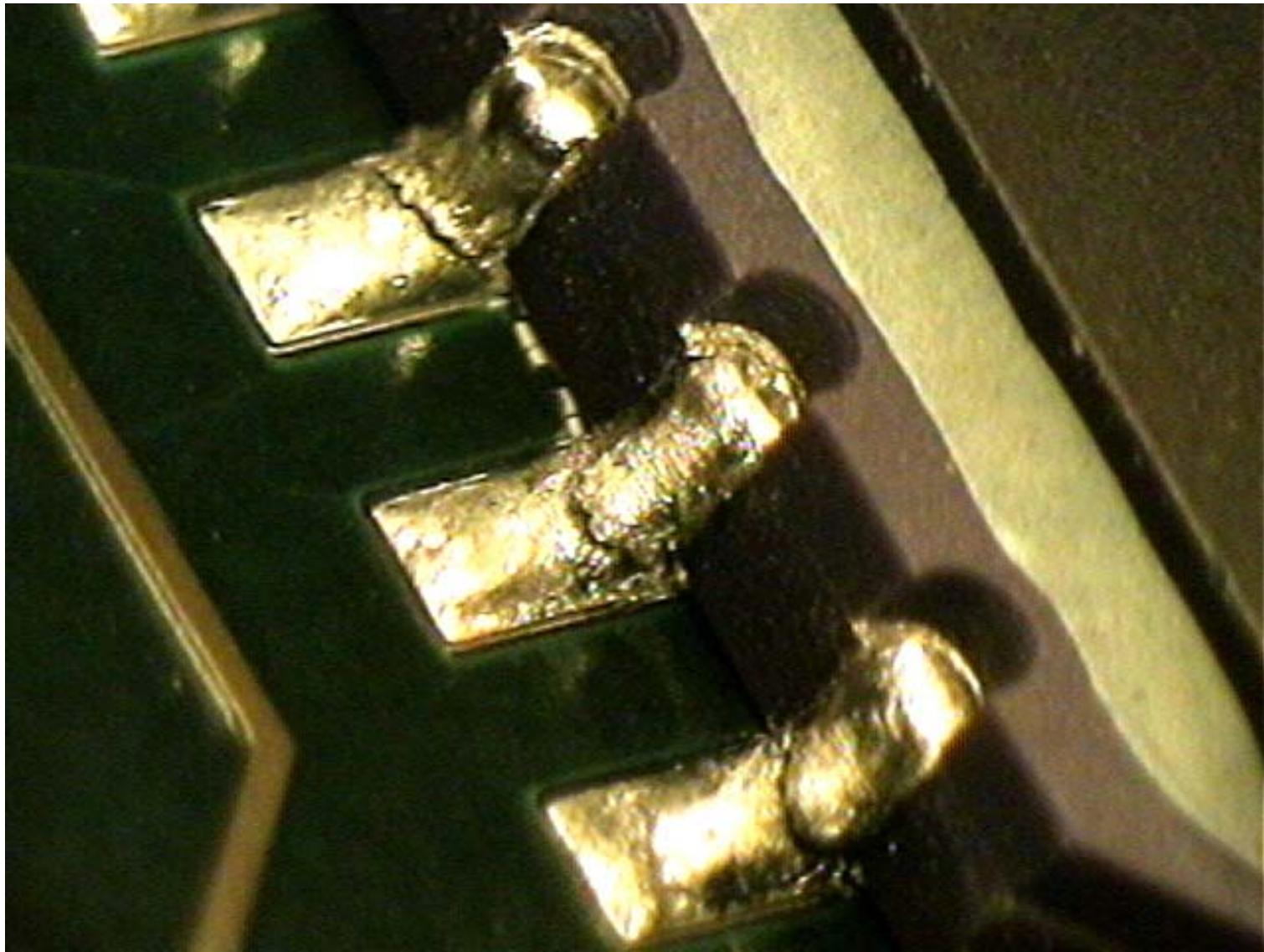


Figure 13. Vehicle ID 81, CLCC U14, SAC Solder/SAC Component Finish, 75x

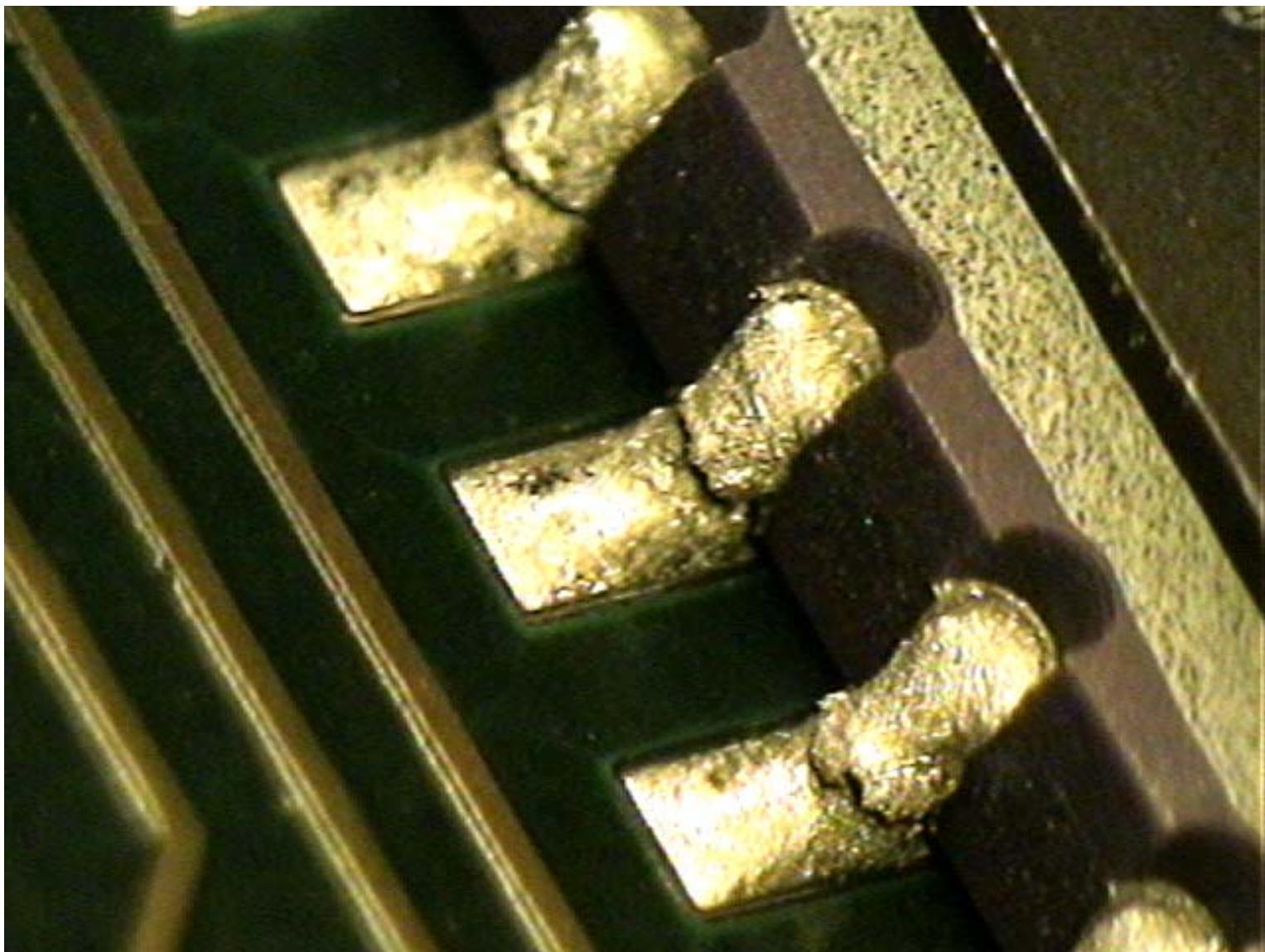


Figure 14. Vehicle ID 81, CLCC U13, SAC Solder/SnPb Component Finish, 75x

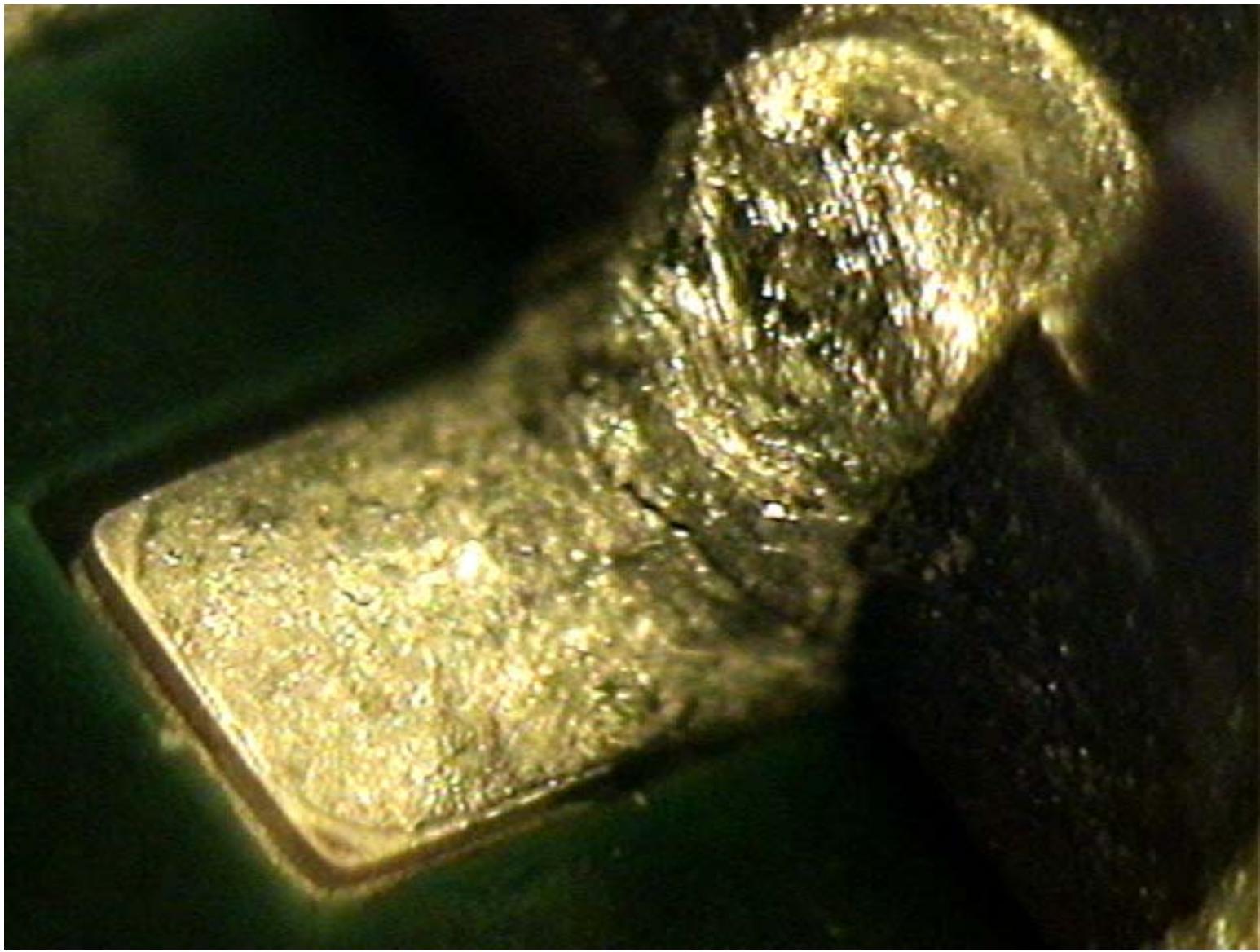


Figure 15. Vehicle ID 119, CLCC U14, SACB Solder/SACB Component Finish, 200x

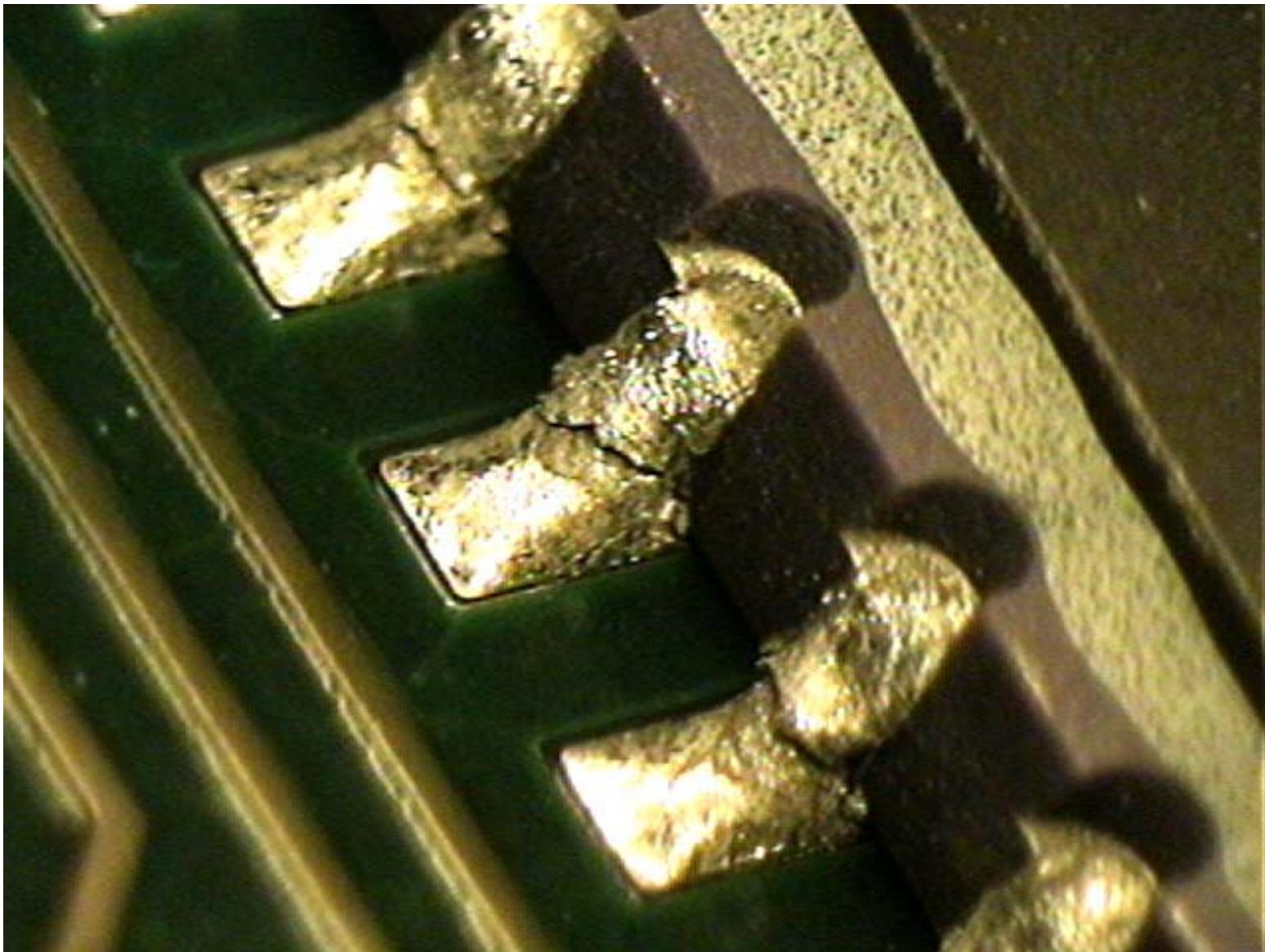


Figure 16. Vehicle ID 119, CLCC U13, SACB Solder/SnPb Component Finish, 75x

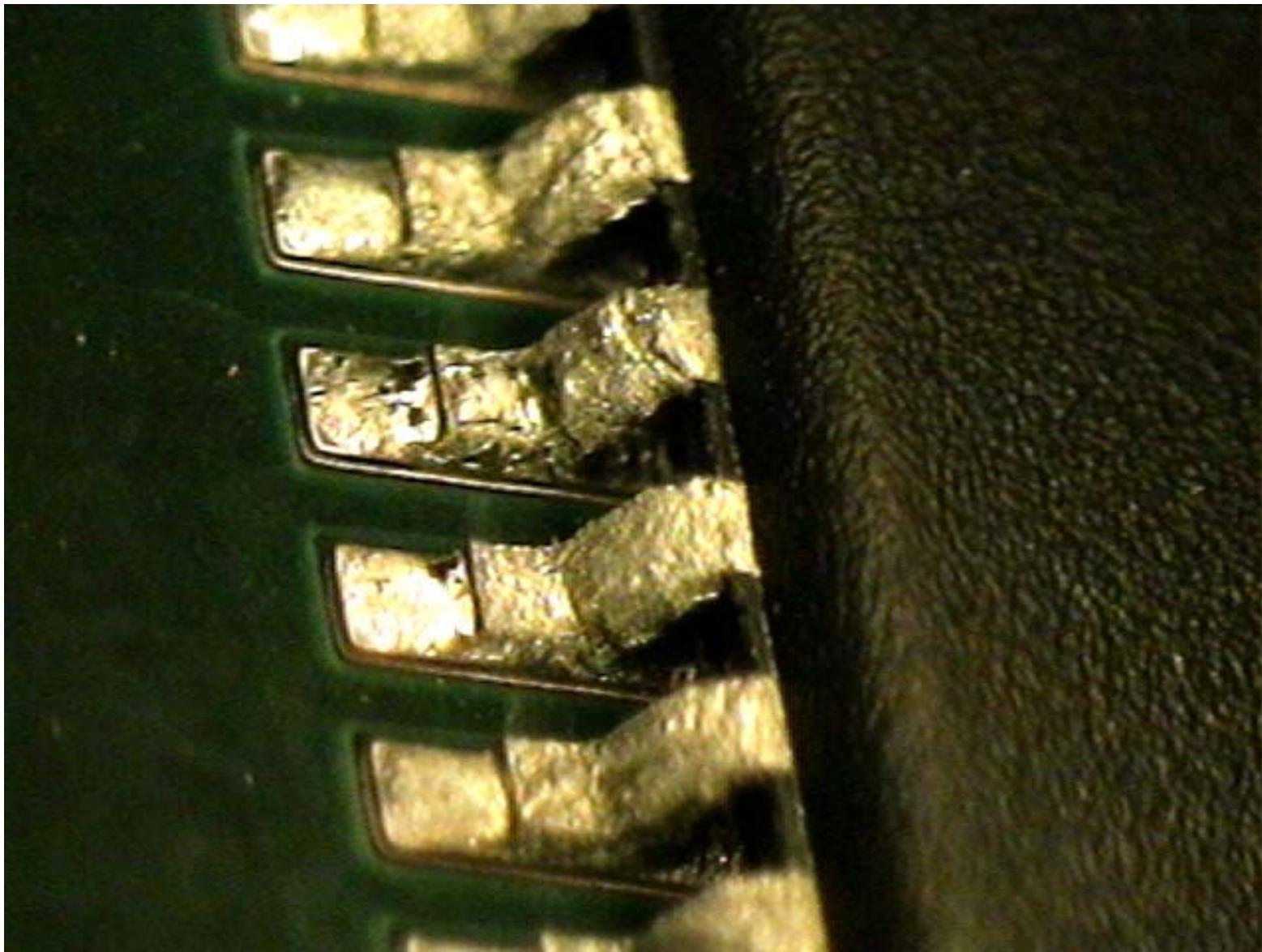


Figure 17. Vehicle ID 1, TSOP U16, SnPb Solder/SnPb Component Finish, 75x

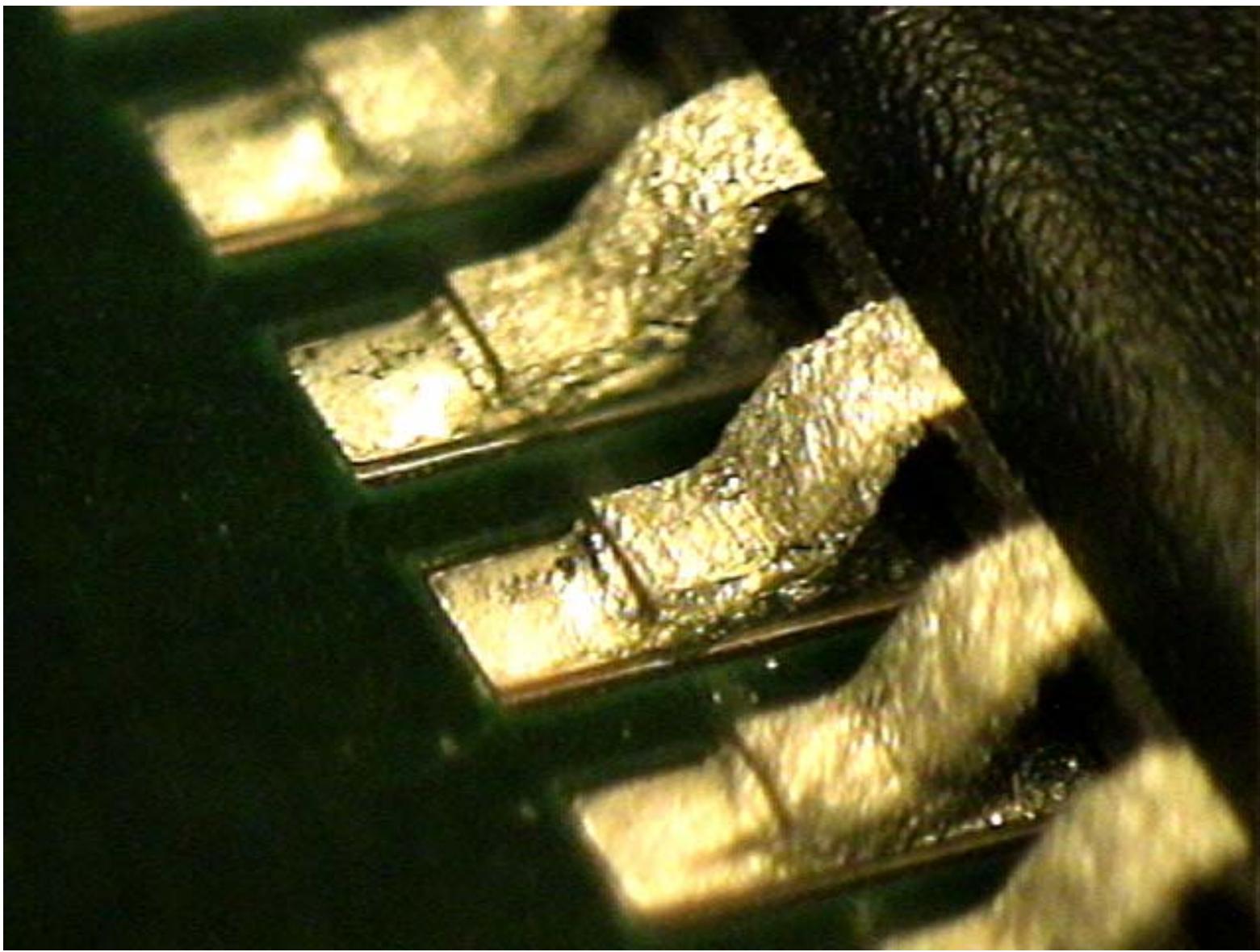


Figure 18. Vehicle ID 81, TSOP U16, SAC Solder/SnPb Component Finish, 100x

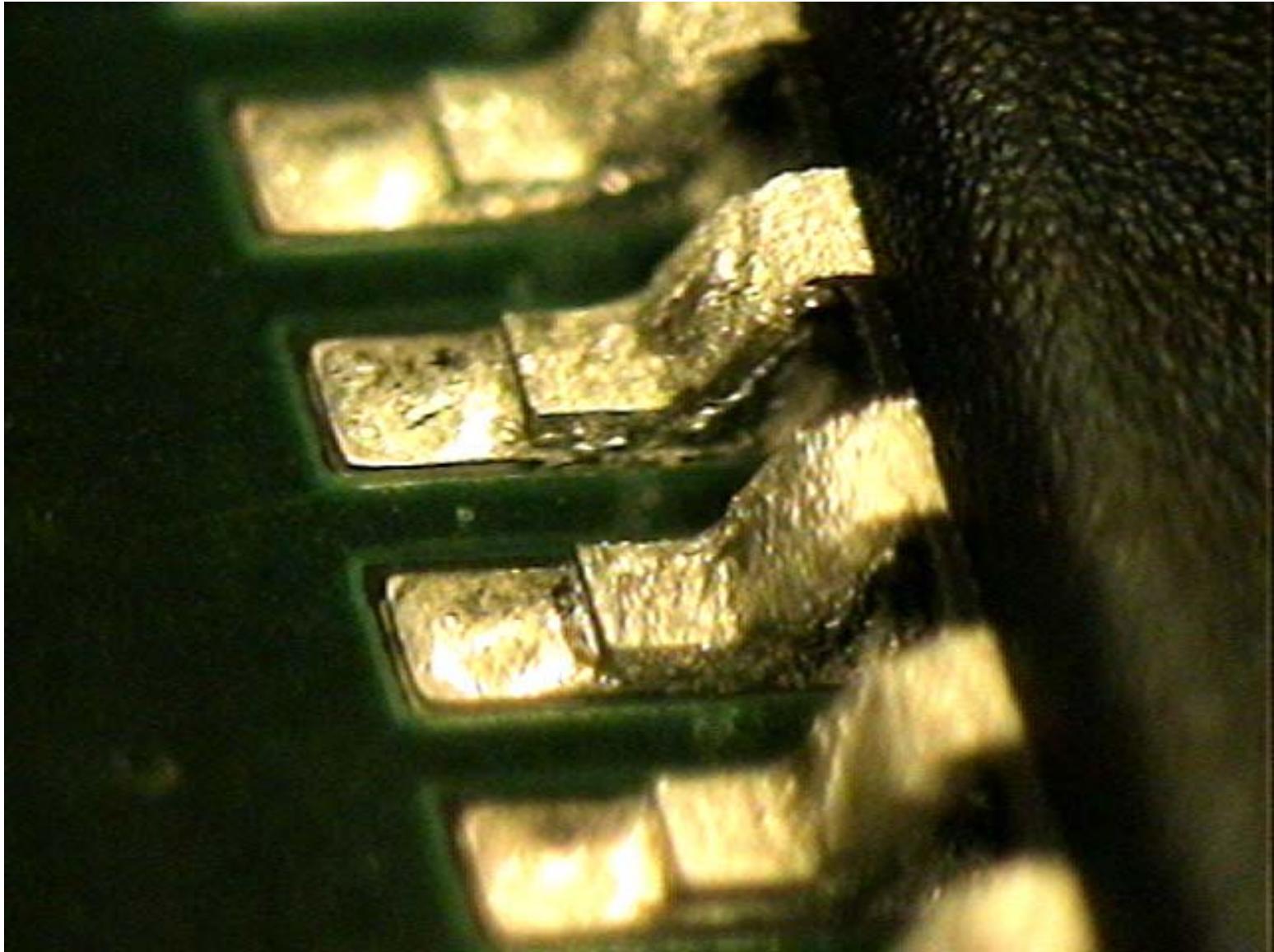


Figure 19. Vehicle ID 119, TSOP U29, SACB Solder/SnCu Component Finish, 100x

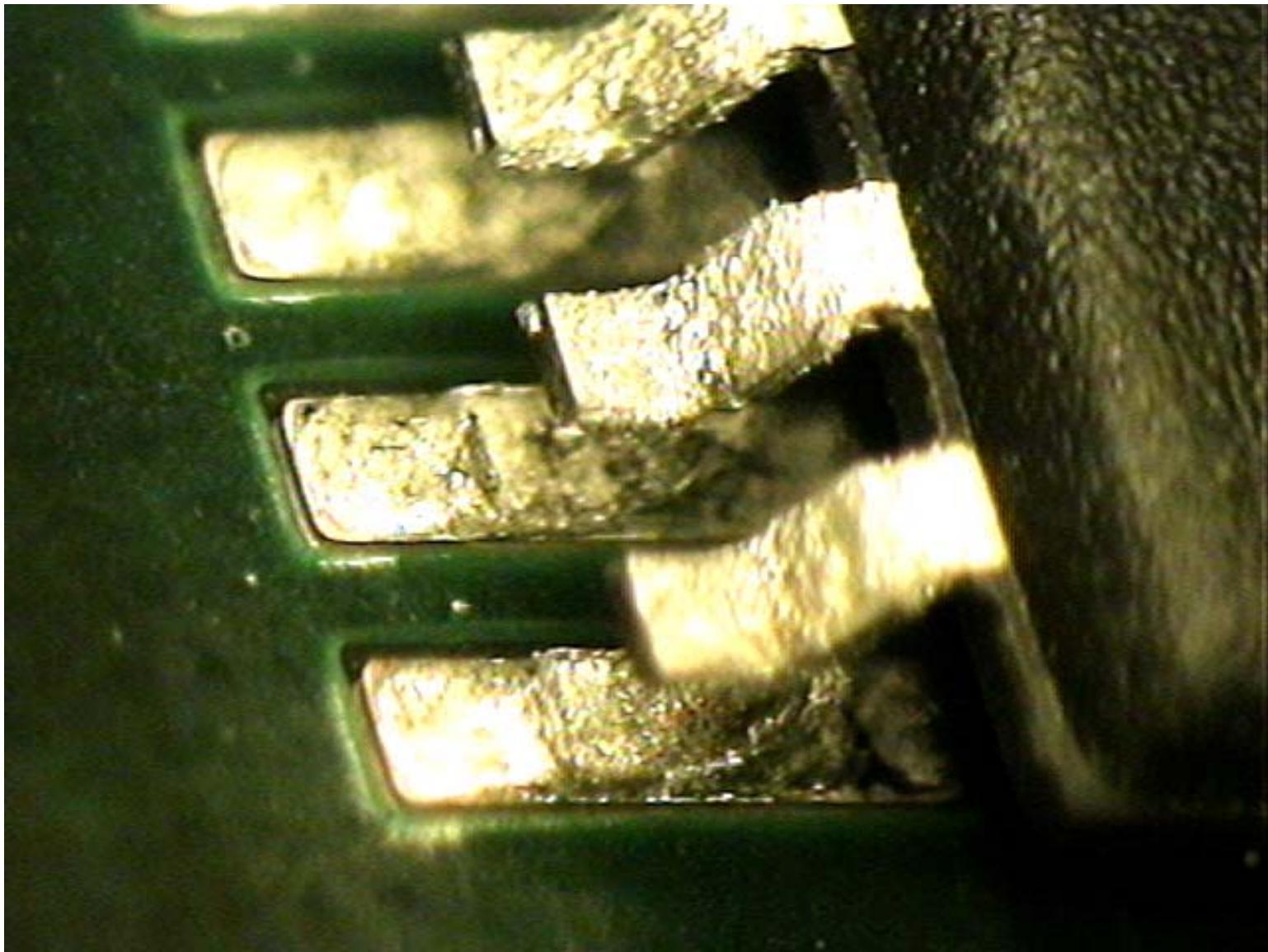


Figure 20. Vehicle ID 119, TSOP U16, SACB Solder/SnPb Component Finish, 100x

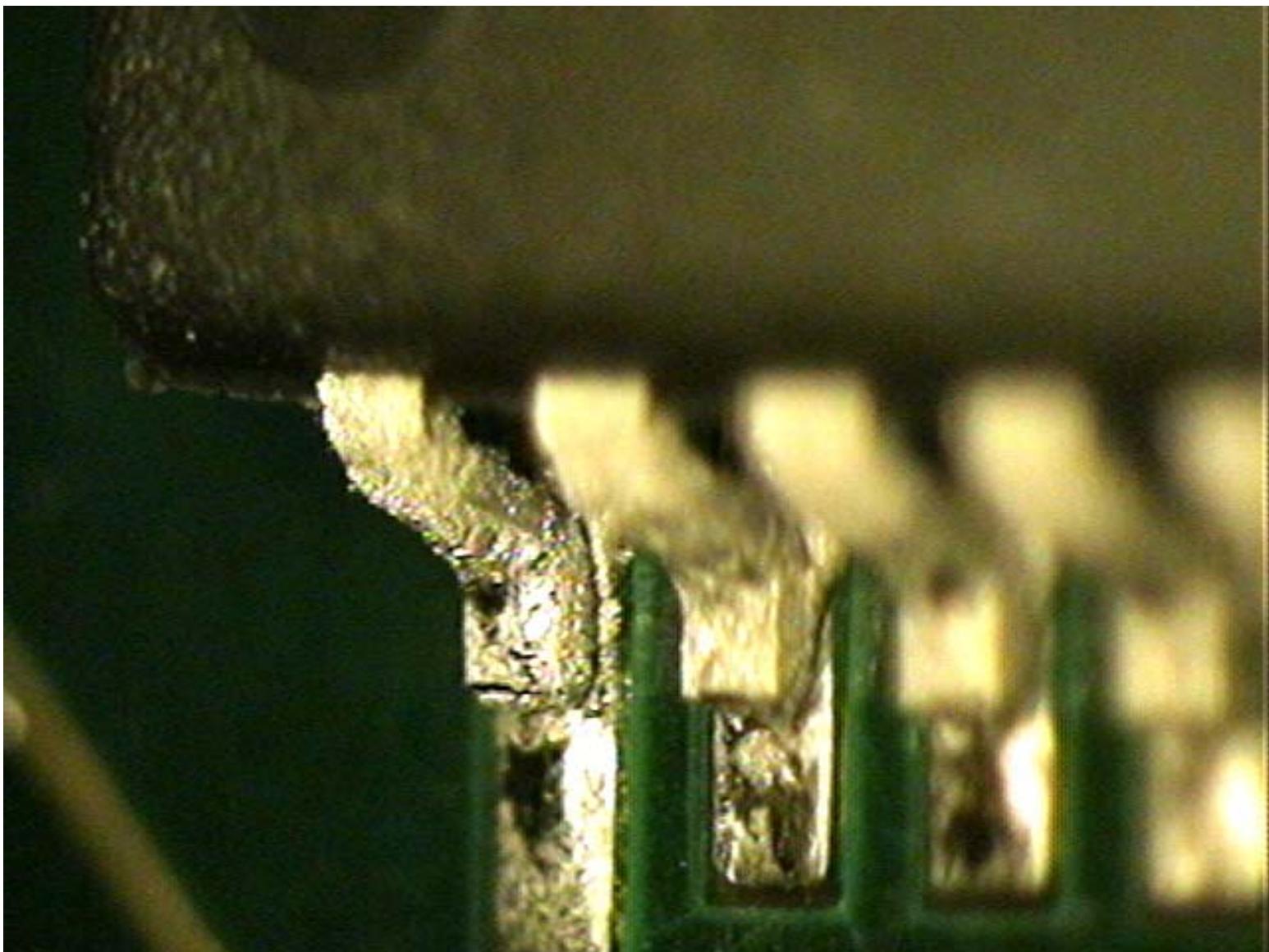


Figure 21. Vehicle ID 52, Reworked TSOP U25, SnPb Solder/SnPb Component Finish, 100x

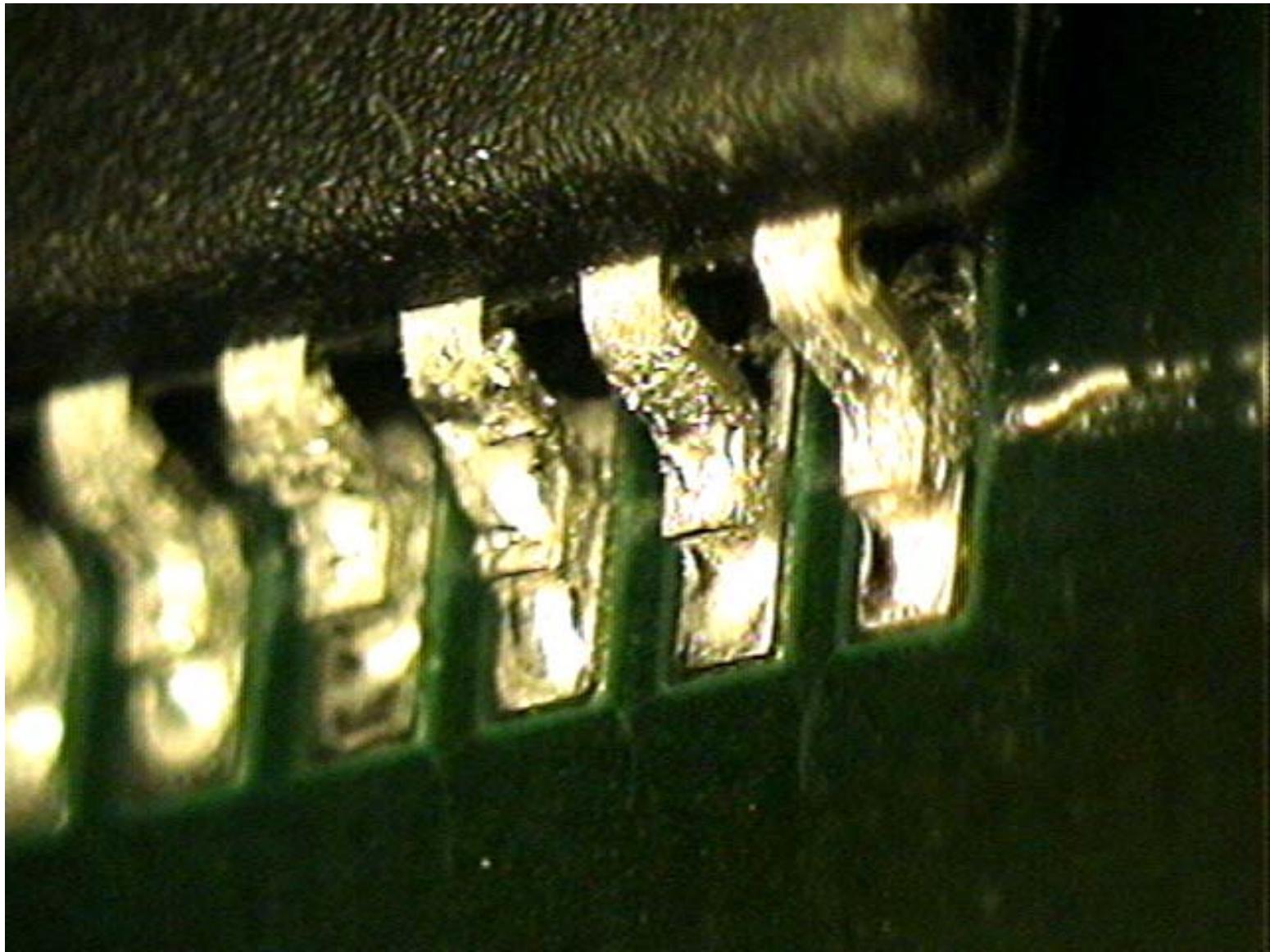


Figure 22. Vehicle ID 160, Reworked TSOP U25, SAC Solder/SnCu Component Finish, 150x

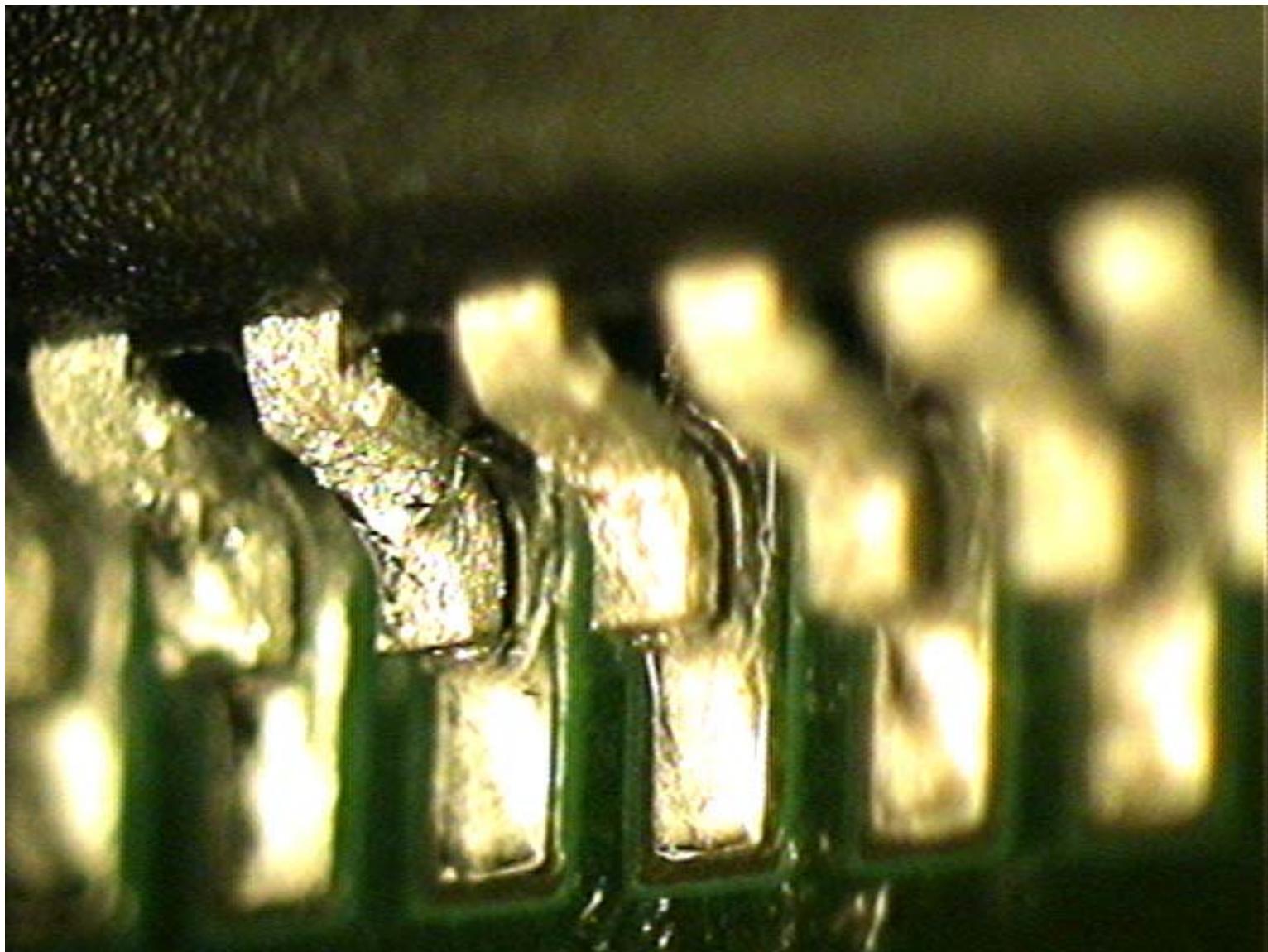


Figure 23. Vehicle ID 188, Reworked TSOP U25, SACB Solder/SnCu Component Finish, 100x

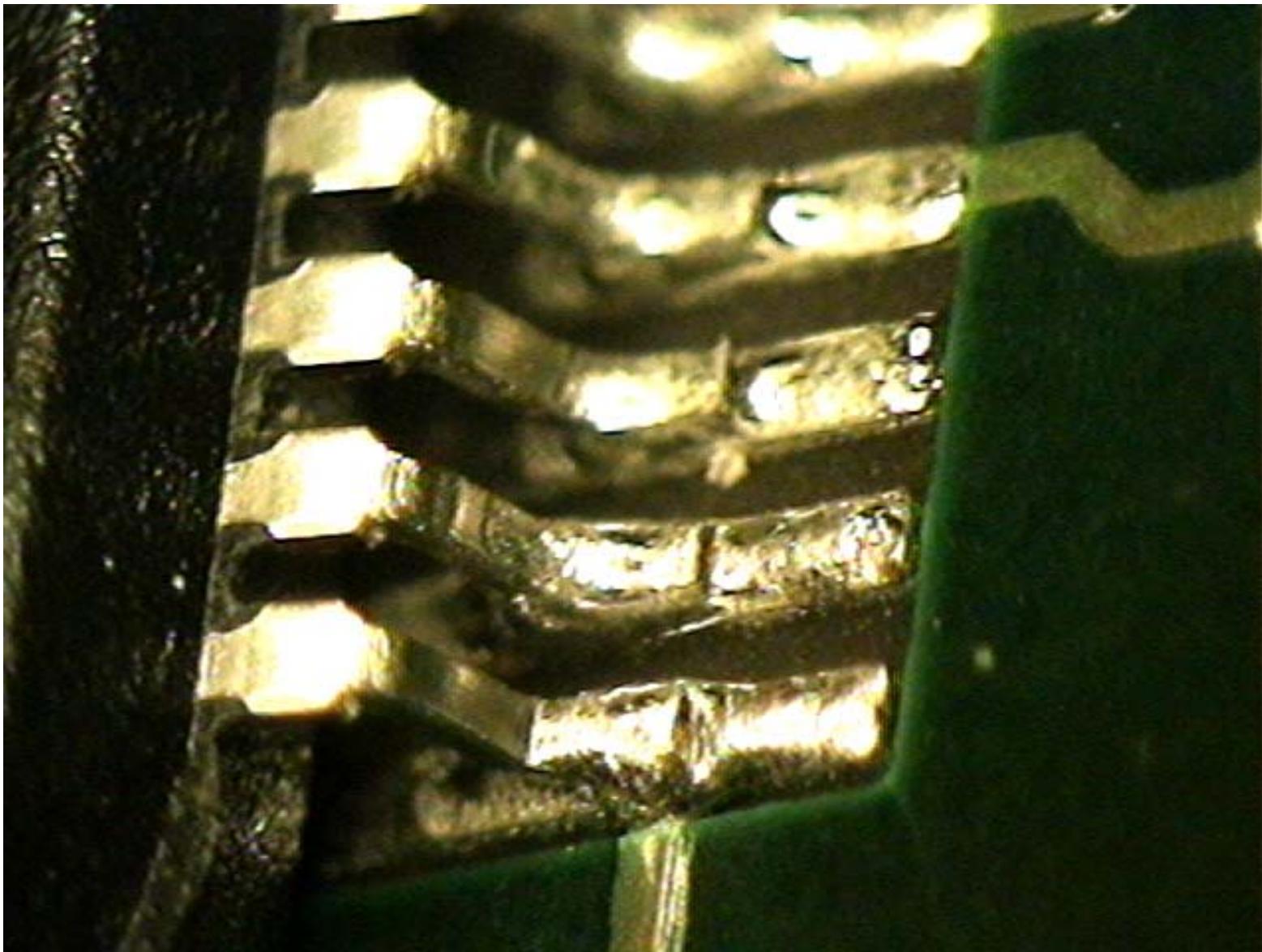


Figure 24. Vehicle ID 52, Reworked TQFP-208 U3, SnPb Solder/NiPdAu Component Finish, 100x

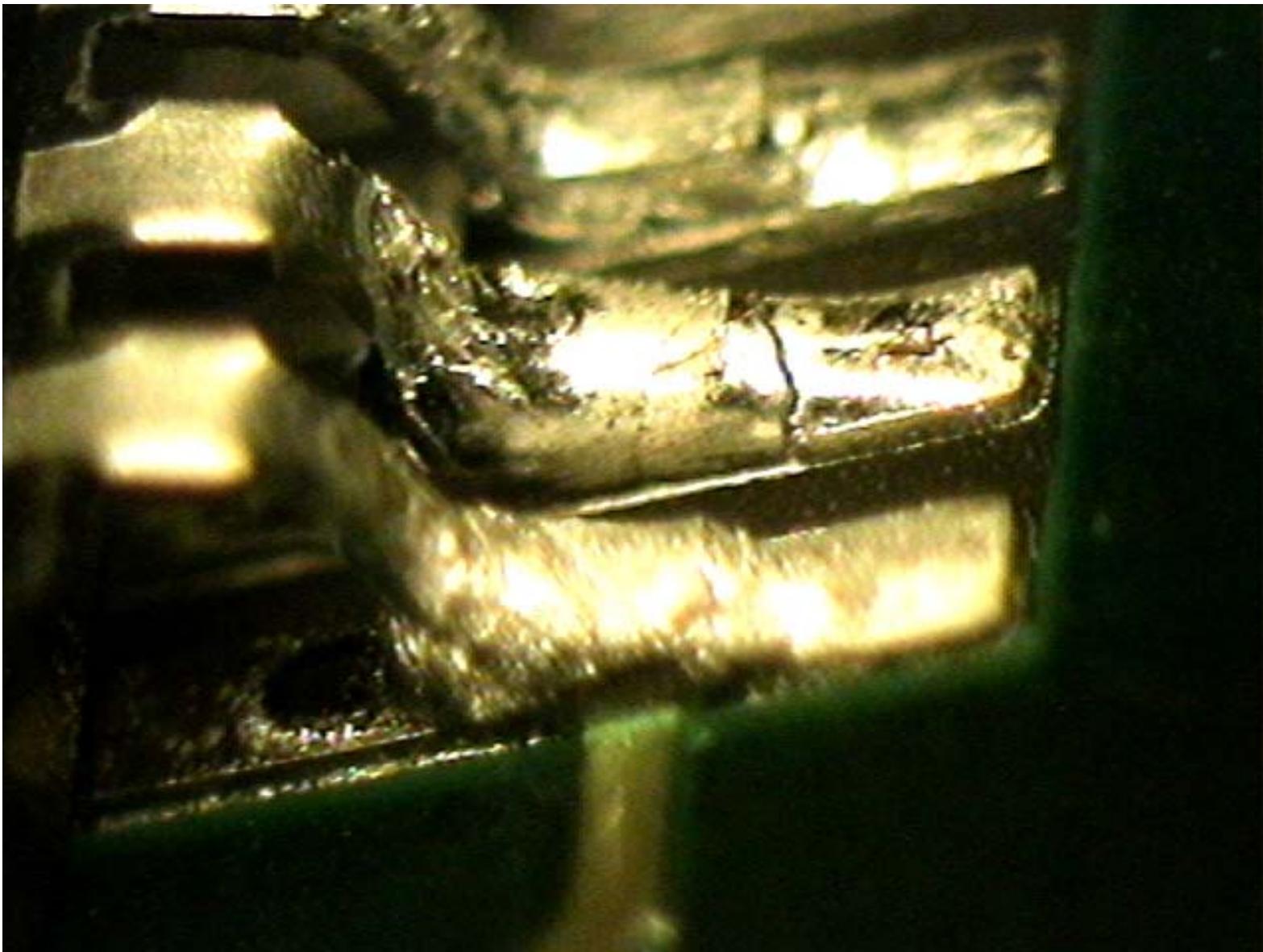


Figure 25. Vehicle ID 160, Reworked TQFP-208 U3, SAC Solder/NiPdAu Component Finish, 150x

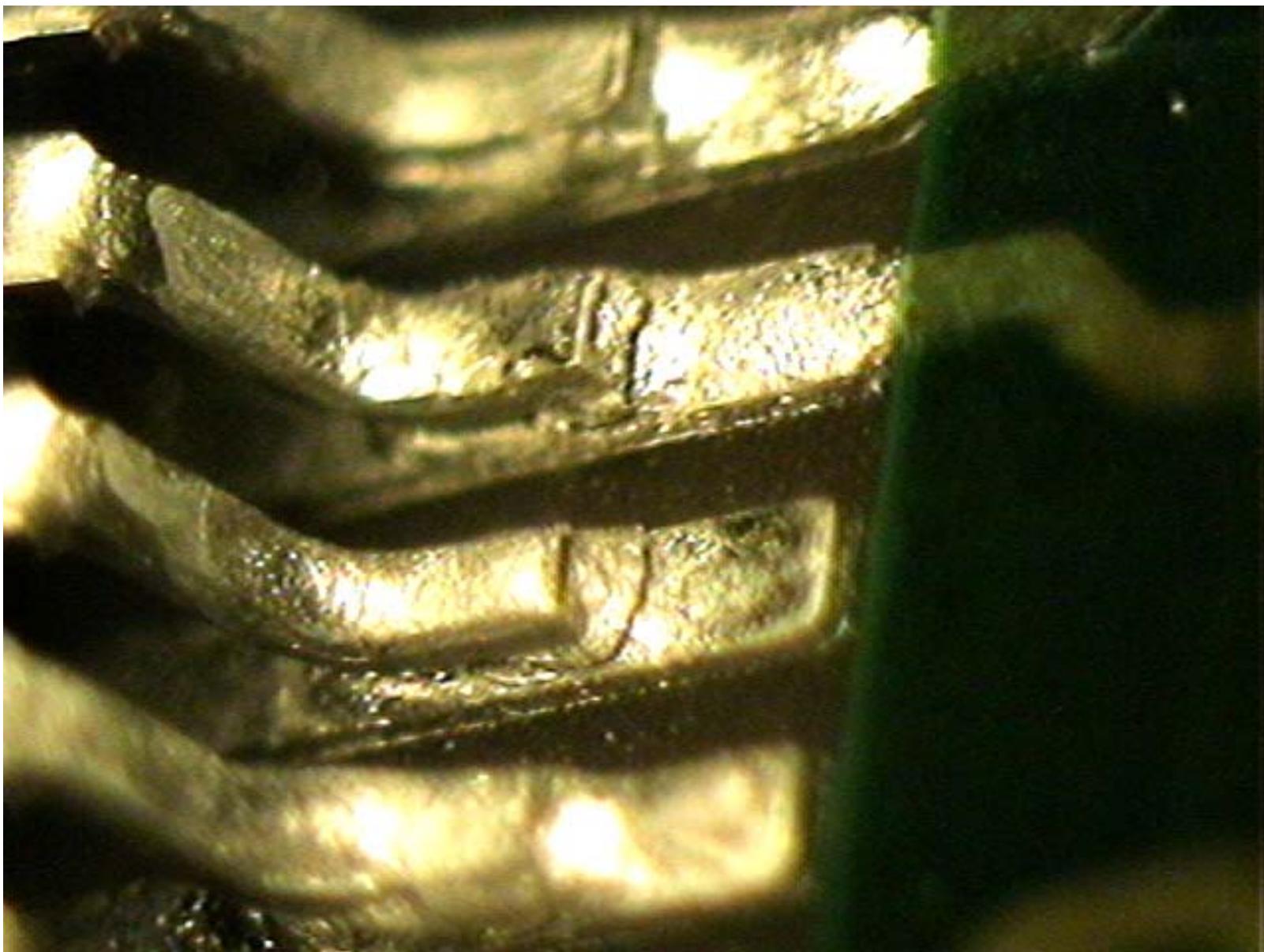


Figure 26. Vehicle ID 188, Reworked TQFP-208 U3, SACB Solder/NiPdAu Component Finish, 150x



Figure 27. Vehicle ID 52, CLCC U13, SnPbSolder/SnPb Component Finish, 50x

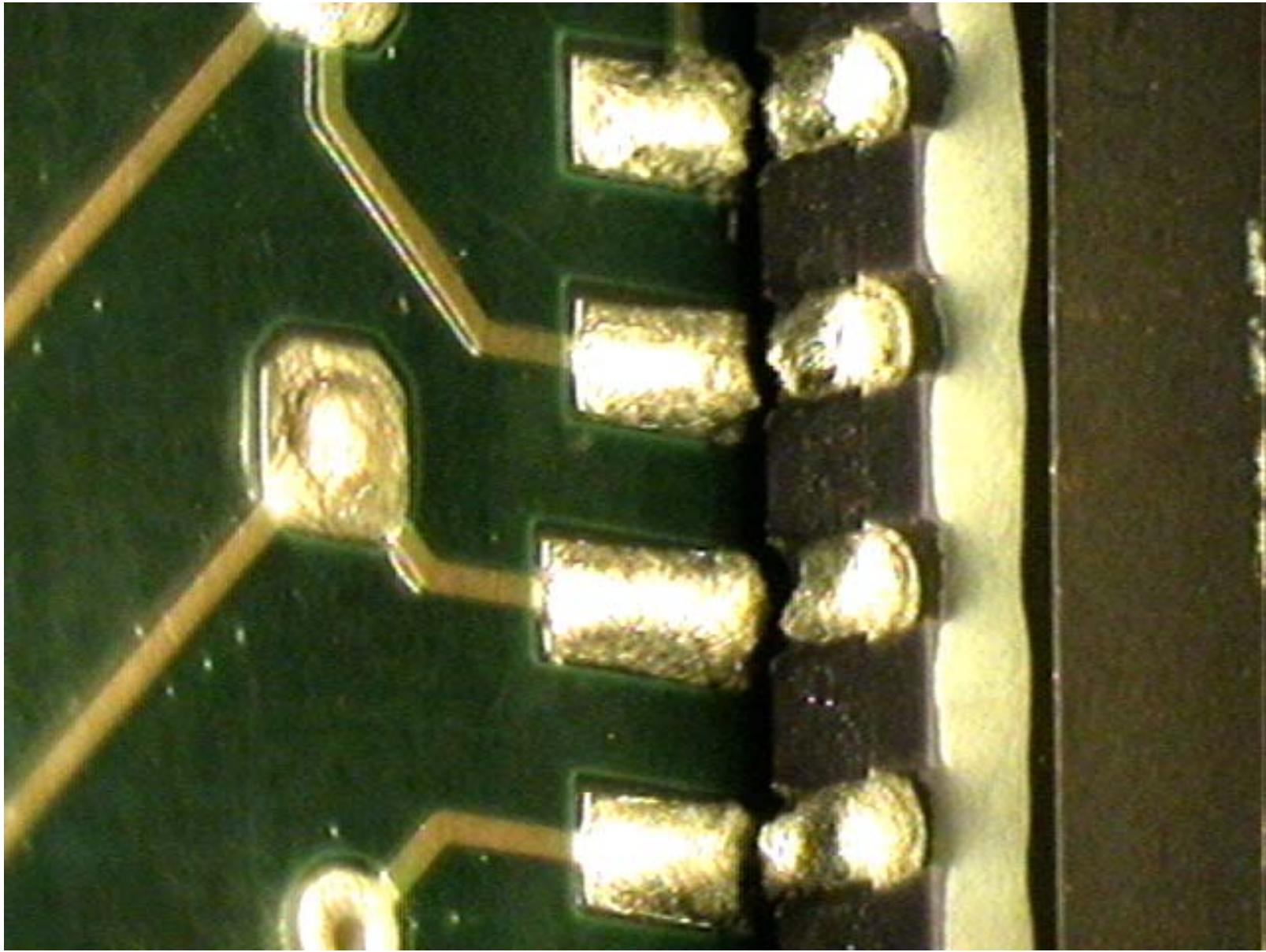


Figure 28. Vehicle ID 160, CLCC U13, SnPbSolder/SAC Component Finish, 50x

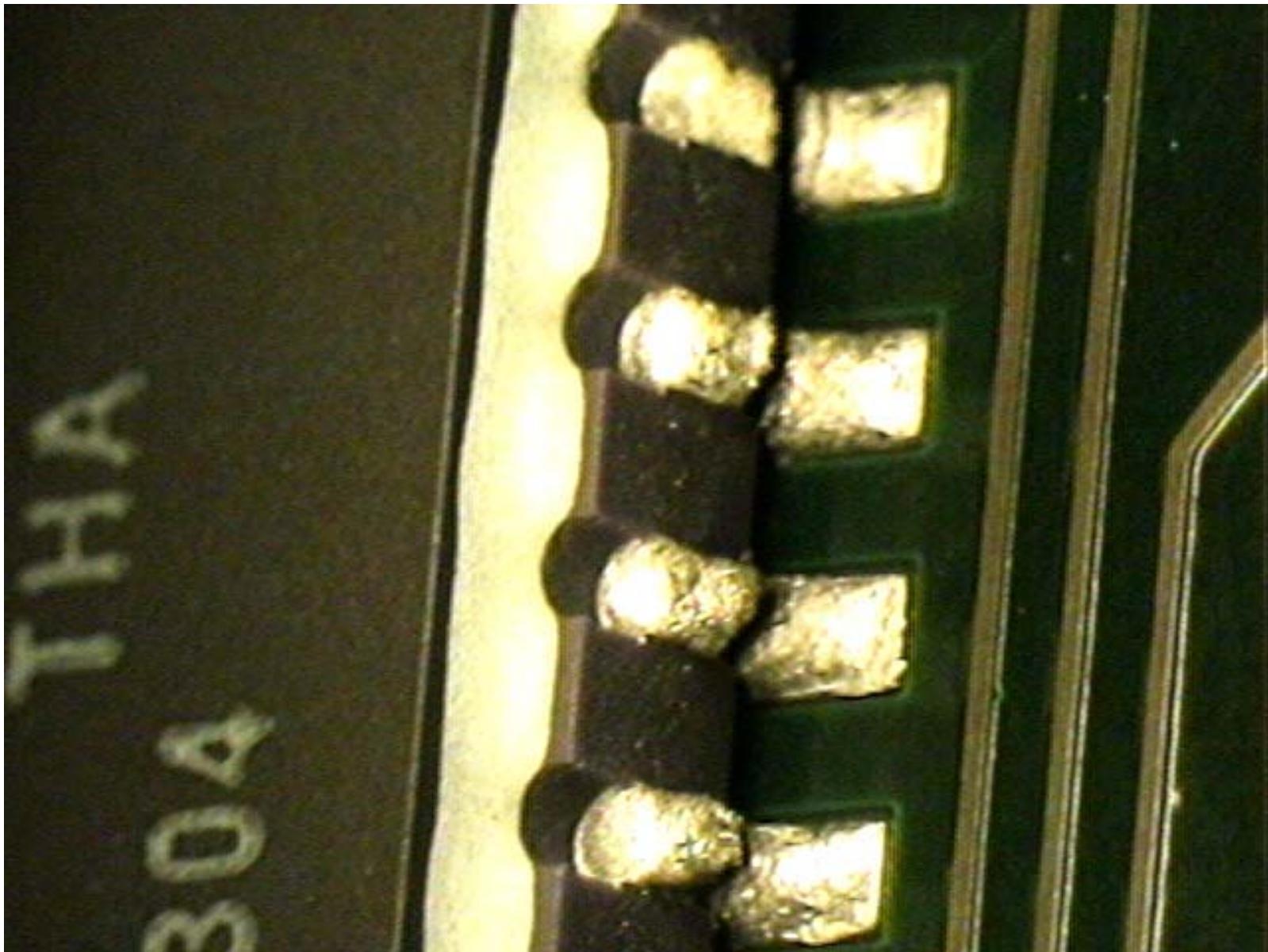


Figure 29. Vehicle ID 188, CLCC U13, SnPbSolder/SACB Component Finish, 50x

**Table 6. Components that were Failed before Testing Began
("Manufactured" Test Vehicles)**

Test Vehicle ID	Component	Ref Designator	Solder Alloy	Component Finish	Reworked?
84	BGA	U5	SnAgCu	SnPb	No
80	PDIP	U35	SnAgCu	NiPdAu	No
119	PDIP	U49	SnAgCuBi	NiPdAu	No
12	PDIP	U63	SnPb	Sn	No
1	TQFP-144	U48	SnPb	SnPb	No

**Table 7. Components that were Failed before Testing Began
("Rework" Test Vehicles)**

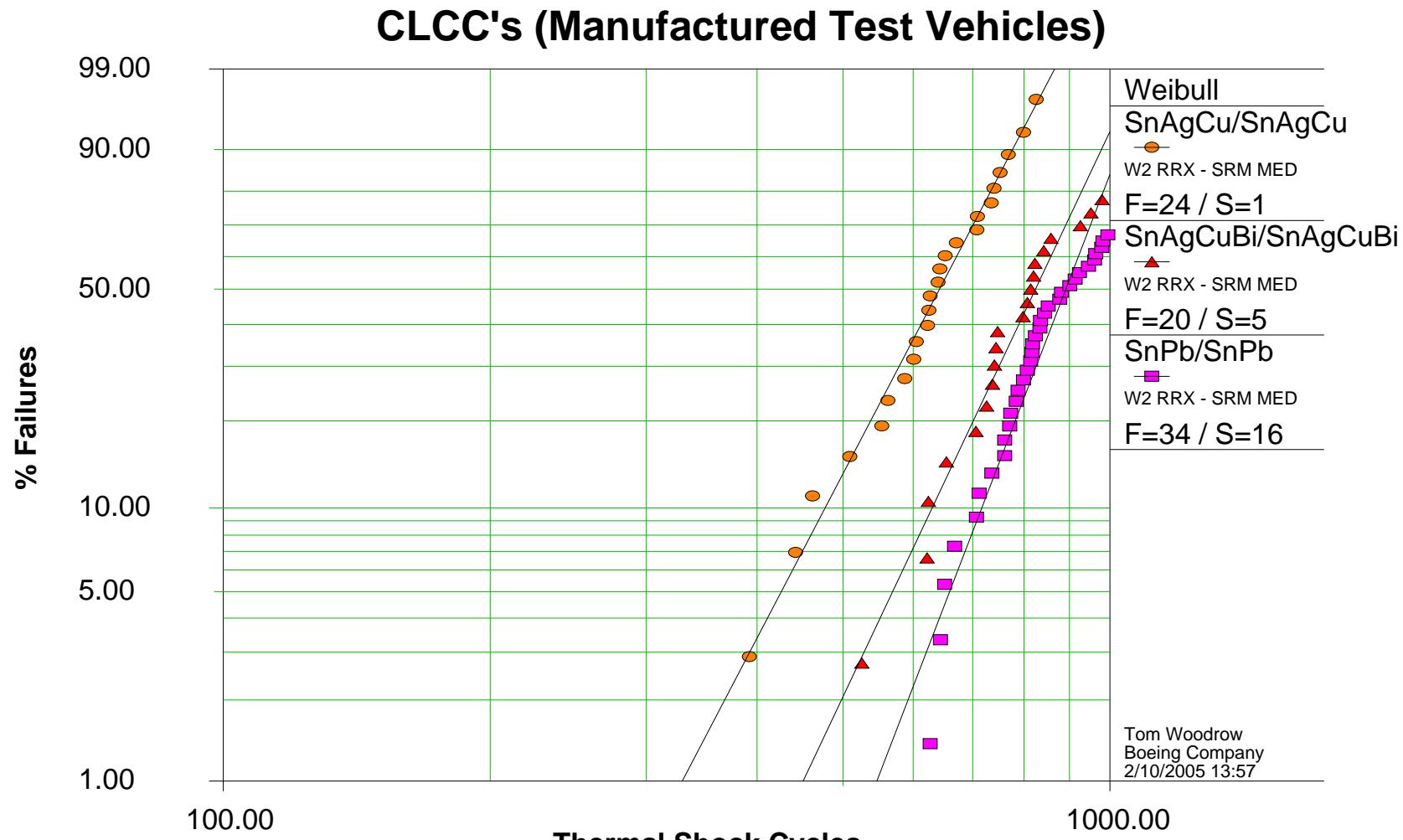
Test Vehicle ID	Component	Ref Designator	Solder Alloy	Component Finish	Reworked?
188	PDIP	U35	SnPb	NiPdAu	No
54	PDIP	U23	SnPb	NiPdAu	Yes
187	TQFP-208	U48	SnPb	NiPdAu	No
55	TQFP-208	U31	SnPb	NiPdAu	No
55	TSOP	U12	SnPb	SnPb	Yes

**Table 8. Early and Miscellaneous Failures – Not Shown on Weibull Plots
("Manufactured" Test Vehicles)**

Test Vehicle ID	Component	Ref Designator	Cycle When Failed	Solder Alloy	Component Finish	Reworked?
80	BGA	U2	217	SnAgCu	SnPb	No
81	BGA	U44	223	SnAgCu	SnPb	No
82	BGA	U21	162	SnAgCu	SnPb	No
120	BGA	U2	195	SnAgCuBi	SnPb	No
82	BGA	U5	384	SnAgCu	SnPb	No
81	BGA	U56	443	SnAgCu	SnPb	No
84	BGA	U21	847	SnAgCu	SnPb	No
10	PDIP	U35	144	SnPb	NiPdAu	No
81	PDIP	U11	86	SnAgCu	Sn	No
14	PDIP	U23	935	SnPb	NiPdAu	No
82	TQFP-144	U58	192	SnAgCu	Sn	No
81	TSOP	U24	229	SnAgCu	SnPb	No
82	TSOP	U25	144	SnAgCu	SnCu	No
81	TSOP	U25	278	SnAgCu	SnCu	No
82	TSOP	U62	250	SnAgCu	SnPb	No

**Table 9. Early and Miscellaneous Failures – Not Shown on Weibull Plots
("Rework" Test Vehicles)**

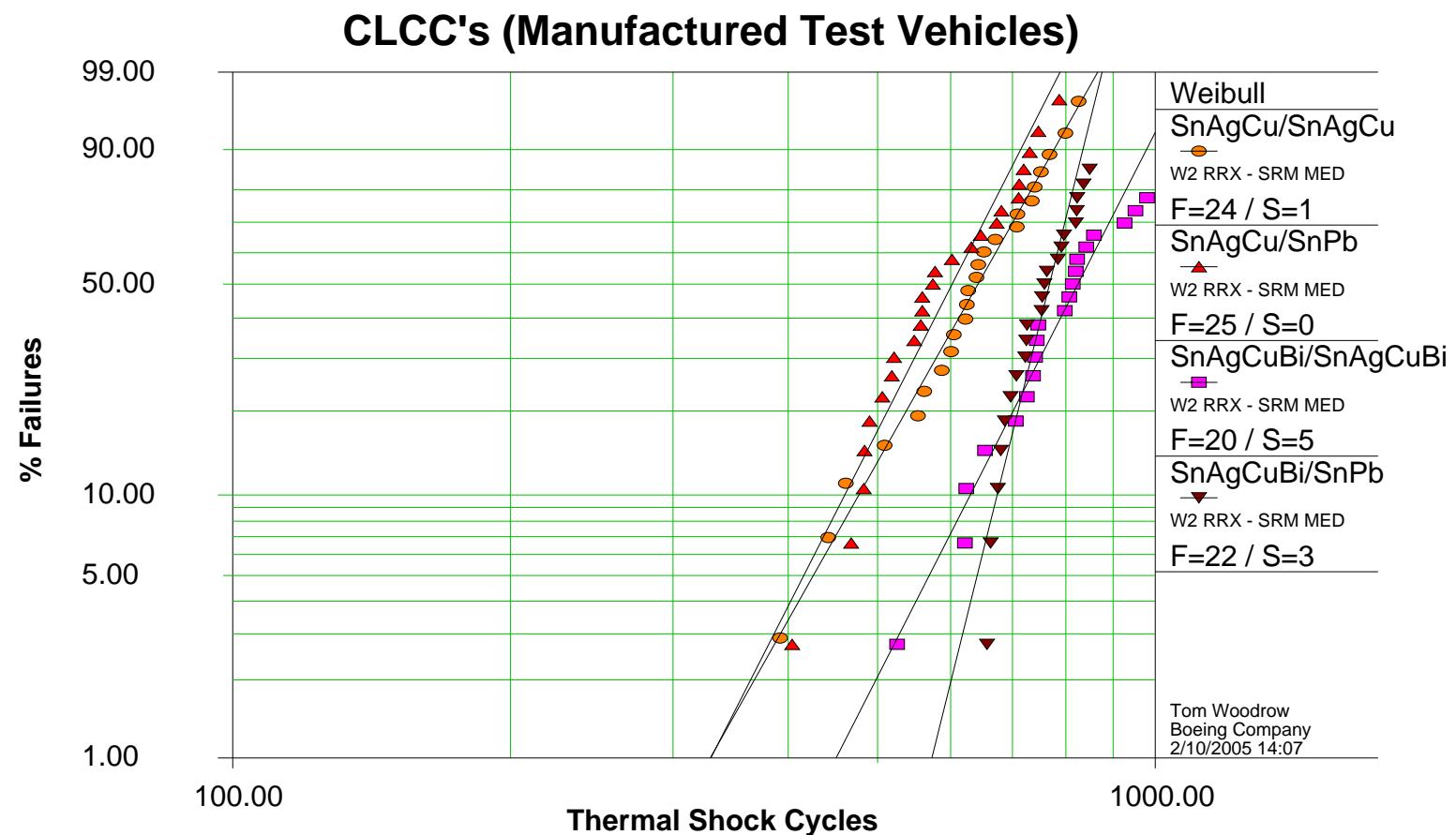
Test Vehicle ID	Component	Ref Designator	Cycle When Failed	Solder Alloy	Component Finish	Reworked?
190	PDIP	U59	225	SnAgCuBi	NiPdAu	Yes



$$\begin{aligned}\beta_1 &= 6.3358, \eta_1 = 680.9641, \rho = 0.9940 \\ \beta_2 &= 7.0173, \eta_2 = 868.6463, \rho = 0.9798 \\ \beta_3 &= 8.6265, \eta_3 = 930.7937, \rho = 0.9652\end{aligned}$$

Key: Solder Alloy/Component Finish

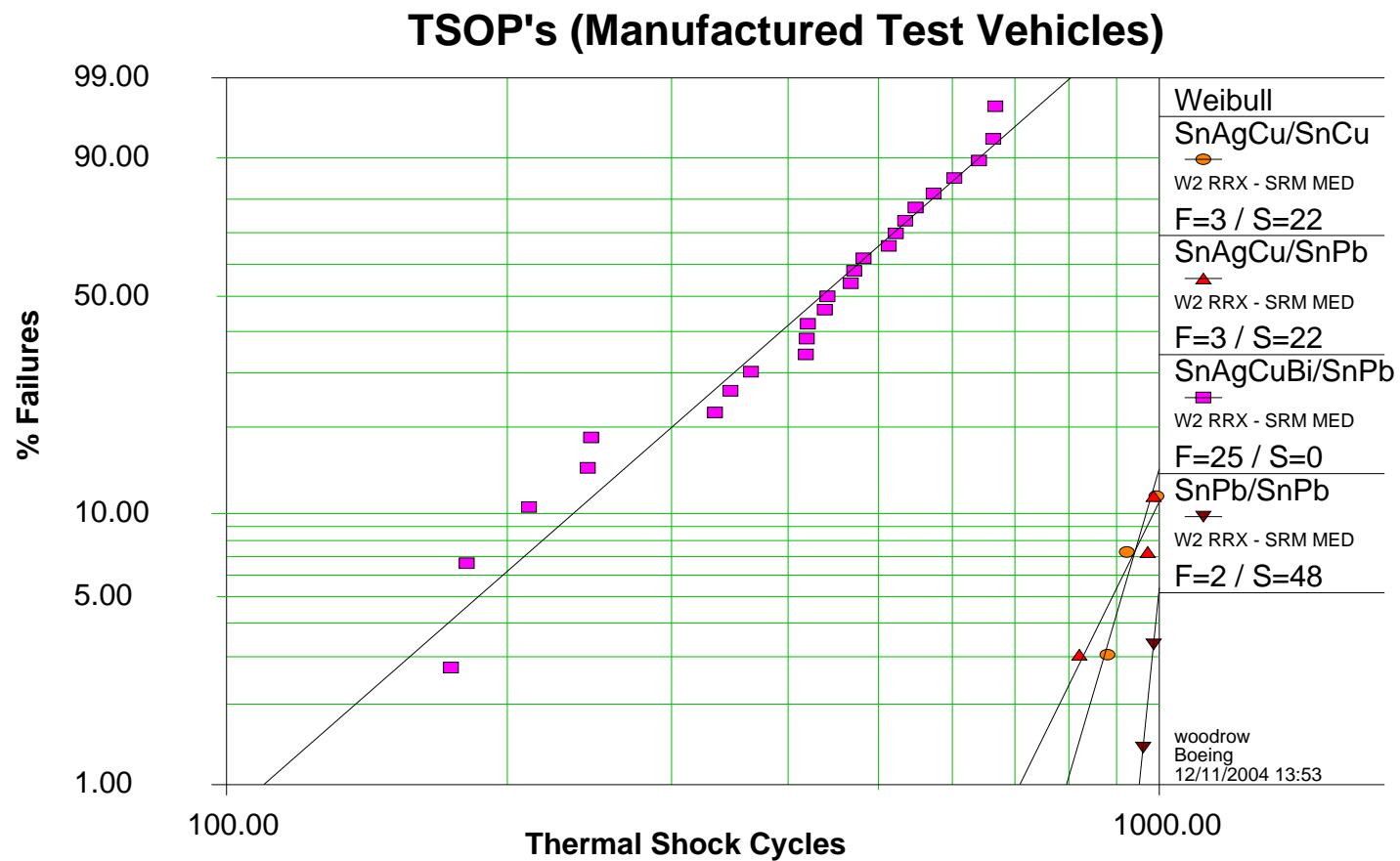
Figure 30. Weibull Plot of CLCC Data (Manufactured Test Vehicles)



$$\begin{aligned}\beta_1 &= 6.3358, \eta_1 = 680.9641, \rho = 0.9940 \\ \beta_2 &= 7.0277, \eta_2 = 634.9372, \rho = 0.9721 \\ \beta_3 &= 7.0173, \eta_3 = 868.6463, \rho = 0.9798 \\ \beta_4 &= 14.4246, \eta_4 = 787.9753, \rho = 0.9529\end{aligned}$$

Key: Solder Alloy/Component Finish

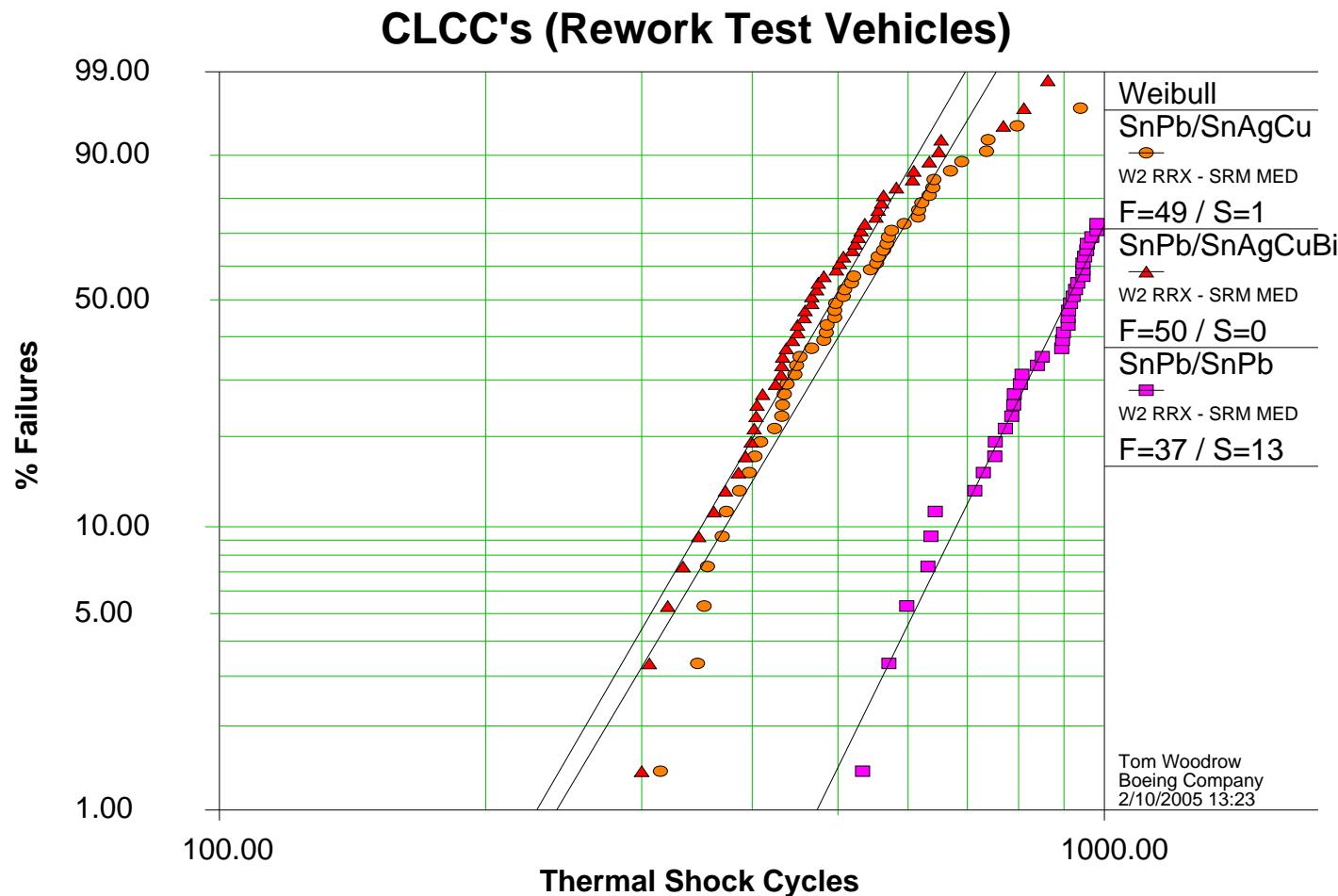
Figure 31. Weibull Plot of CLCC Data Showing Effects of Mixing SnPb with Pb-Free Solders (Manufactured Test Vehicles)



$\beta_1=11.9560, \eta_1=1168.4790, \rho=0.9583$
 $\beta_2=7.1307, \eta_2=1351.6275, \rho=0.9599$
 $\beta_3=3.0770, \eta_3=489.0307, \rho=0.9817$
 $\beta_4=34.8281, \eta_4=1086.6141, \rho=1.0000$

Key: Solder Alloy/Component Finish

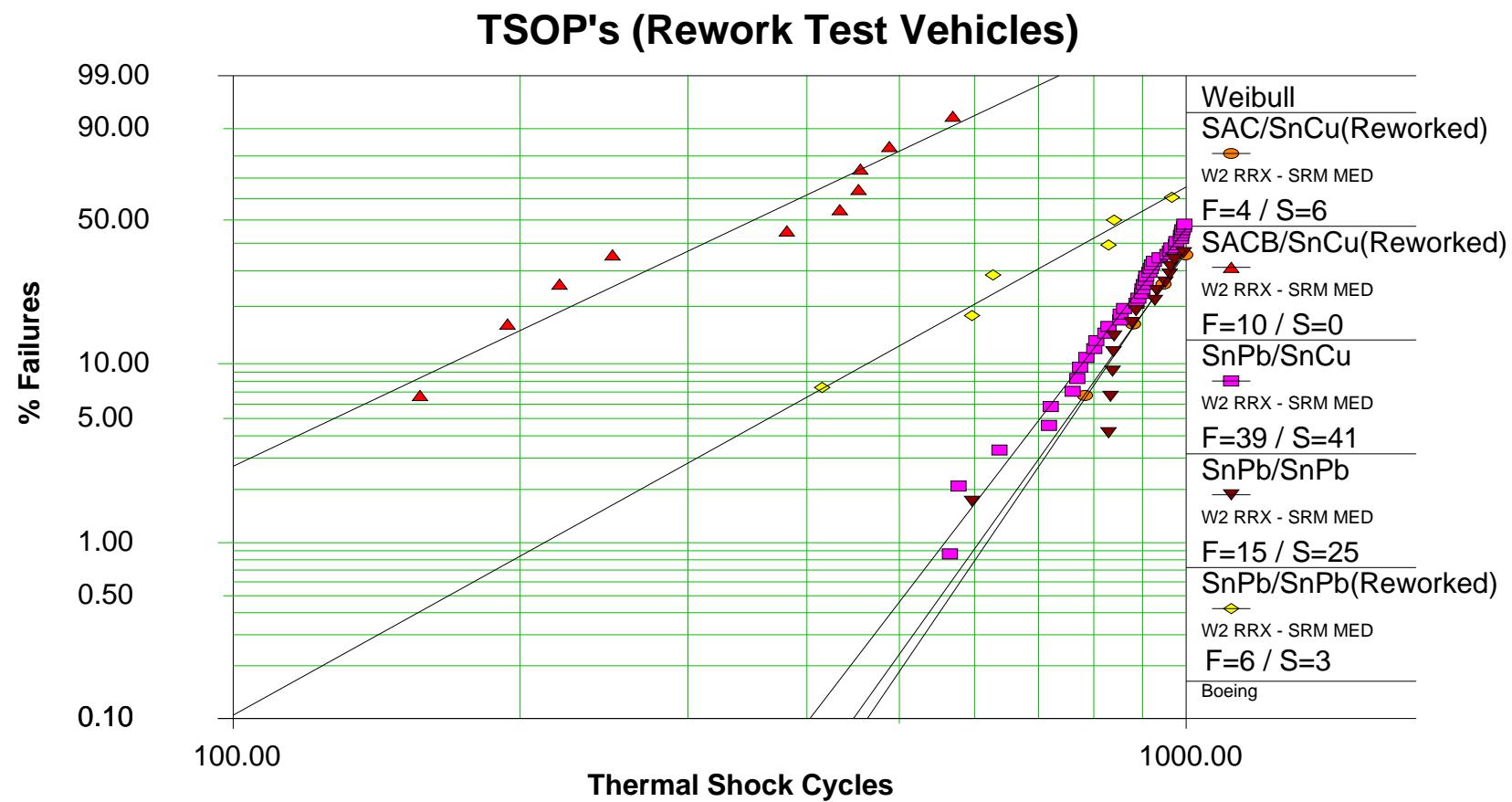
Figure 32. Weibull Plot of TSOP Data (Manufactured Test Vehicles)



$\beta_1=5.3570, \eta_1=567.7017, \rho=0.9539$
 $\beta_2=5.4933, \eta_2=527.6326, \rho=0.9546$
 $\beta_3=6.4963, \eta_3=961.2732, \rho=0.9878$

Key: Solder Alloy/Component Finish

Figure 33. Weibull Plot of CLCC Data (Rework Test Vehicles)

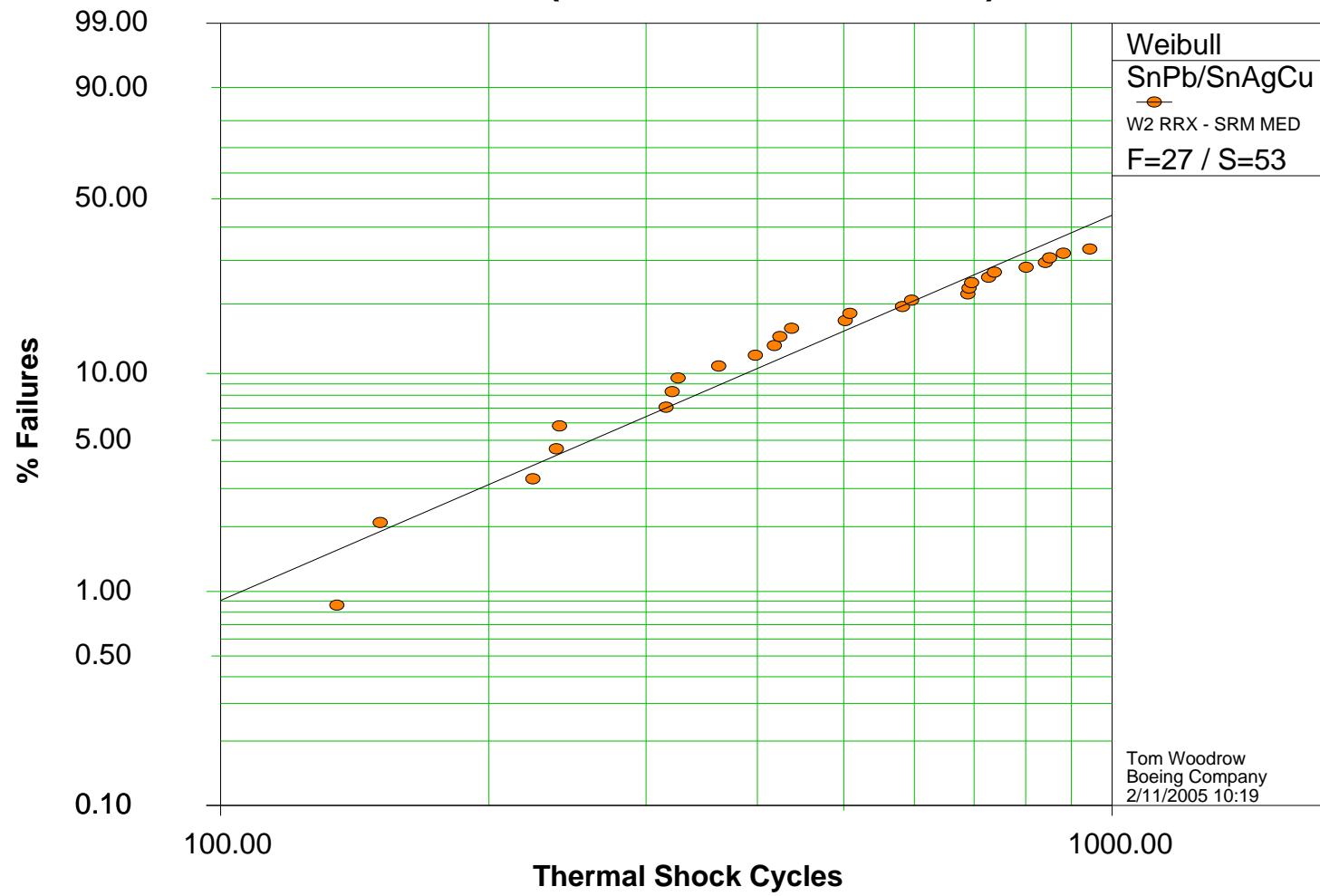


$\beta_1=7.6062$, $\eta_1=1109.7659$, $\rho=0.9996$
 $\beta_2=2.5678$, $\eta_2=406.0219$, $\rho=0.9679$
 $\beta_3=7.0809$, $\eta_3=1068.9521$, $\rho=0.9921$
 $\beta_4=7.9890$, $\eta_4=1099.1031$, $\rho=0.9296$
 $\beta_5=3.0105$, $\eta_5=977.8470$, $\rho=0.9850$

Key: Solder Alloy/Component Finish

Figure 34. Weibull Plot of TSOP Data Showing Effects of Rework (Rework Test Vehicles)

BGA's (Rework Test Vehicles)



Key: Solder Alloy/Component Finish

Figure 35. Weibull Plot of BGA Data (Rework Test Vehicles)

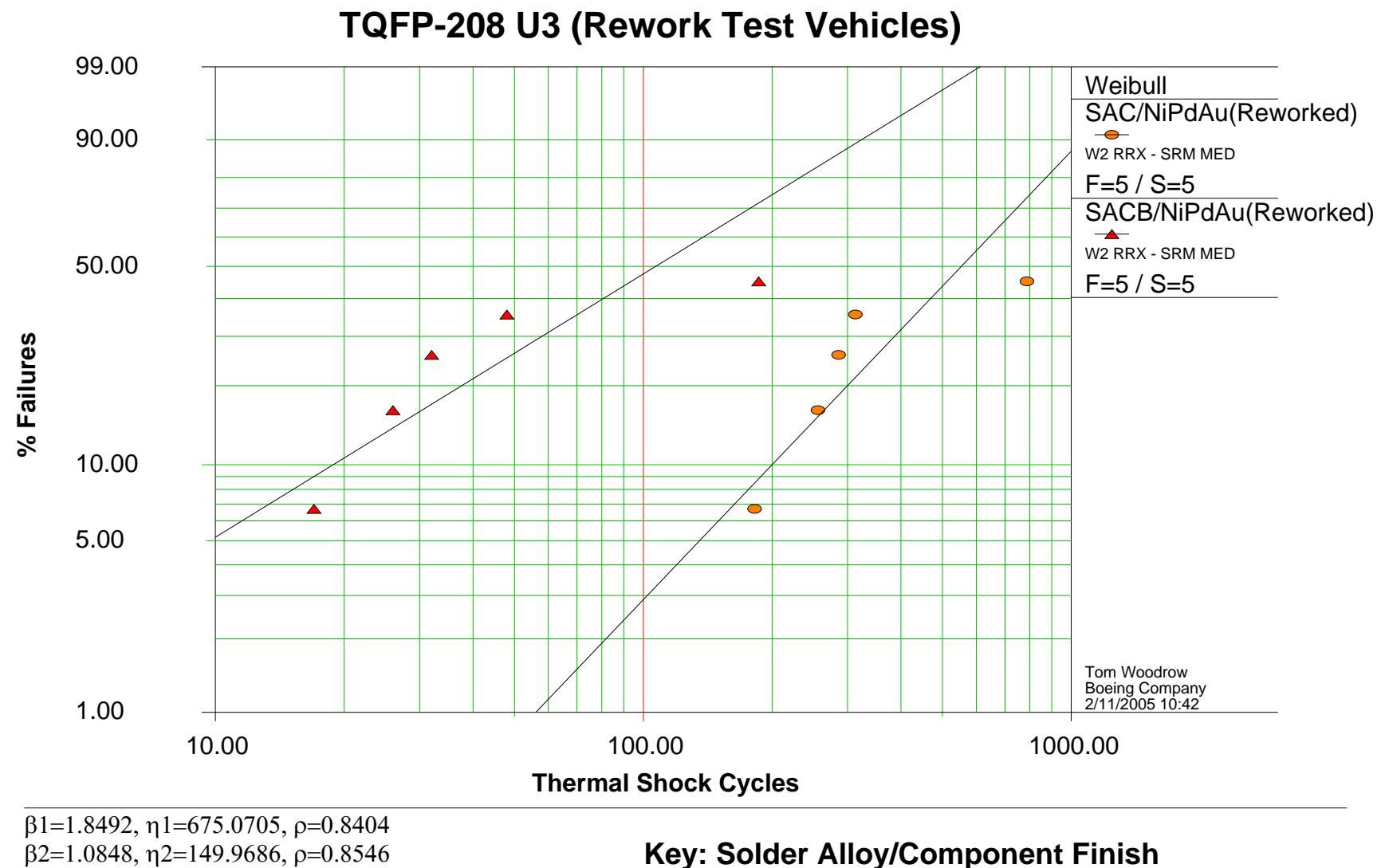


Figure 36. Weibull Plot of TQFP U3 Data (Rework Test Vehicles)

**Appendix A. Literature Search for 2-Parameter Weibull
Data for Solders Used with Various
Component Types**

Table A-1. Literature Search for Weibull Parameters

Component	Solder	Temp Cycle	1st Failure	N_{1%}	Characteristic Life	Beta	Reference
1206 Chip Resistor	Sn37Pb	-55/125°C	2823		5540	5.2	Woodrow 2002
1206 Chip Resistor	Sn3.8Ag0.7Cu	-55/125°C	1181		3866	2.0	Woodrow 2002
1206 Chip Resistor	Sn37Pb	-55/125°C	1900		10055	2.0	NCMS 1997
1206 Chip Resistor	Sn2.6Ag0.8Cu0.5Sb	-55/125°C	1226		5134	1.4	NCMS 1997
1206 Chip Resistor	Sn37Pb	0/100°C	>6673		N/A	N/A	NCMS 1997
1206 Chip Resistor	Sn2.6Ag0.8Cu0.5Sb	0/100°C	1232		5017	1.4	NCMS 1997
Component	Solder	Temp Cycle	1st Failure	N_{1%}	Characteristic Life	Beta	Reference
2512 Chip Resistor	Sn37Pb	-55/125°C		333	746	5.7	Swan 2001
2512 Chip Resistor	Sn3.9Ag0.6Cu	-55/125°C		213	681	4.0	Swan 2001
2512 Chip Resistor	Sn37Pb	0/100°C		1183	2256	7.1	Swan 2001
2512 Chip Resistor	Sn3.9Ag0.6Cu	0/100°C		606	3063	2.8	Swan 2001
2512 Chip Resistor	Sn37Pb	-55/125°C		324	1900	2.6	Dusek 2002
2512 Chip Resistor	Sn3.8Ag0.7Cu	-55/125°C		213	1450	2.4	Dusek 2002
2512 Chip Resistor	Sn3.8Ag0.7Cu2Bi	-55/125°C		333	2100	2.5	Dusek 2002
Component	Solder	Temp Cycle	1st Failure	N_{1%}	Characteristic Life	Beta	Reference
LCCC20	Sn37Pb	-40/125°C	761		1197	8.8	NCMS 2001
LCCC20	Sn3.5Ag	-40/125°C	614		849	9.6	NCMS 2001
LCCC20	Sn37Pb	-40/125°C	878		3350	2.2	Woodrow 2003
LCCC20	Sn3.8Ag0.7Cu	-40/125°C	425		802	5.7	Woodrow 2003
Component	Solder	Temp Cycle	1st Failure	N_{1%}	Characteristic Life	Beta	Reference
TSOP48 (Alloy 42)	Sn37Pb	-55/125°C		373	1000	4.7	Swan 2001
TSOP48 (Alloy 42)	Sn3.9Ag0.6Cu	-55/125°C		111	614	2.7	Swan 2001
TSOP48 (Alloy 42)	Sn37Pb	0/100°C		2333	3500	11.3	Swan 2001
TSOP48 (Alloy 42)	Sn3.9Ag0.6Cu	0/100°C		1092	2564	5.4	Swan 2001
TSOP48 (Alloy 42)	Sn37Pb	-55/125°C (T. Shock)	1904		3455	4.8	Amkor (Syed)
TSOP48 (Alloy 42)	Sn3.9Ag0.6Cu	-55/125°C (T. Shock)	1979		2353	16.2	Amkor (Syed)

Table A-1. Literature Search for Weibull Parameters (Cont'd)

Component	Solder Ball/Paste	Temp Cycle	1st Failure	N _{1%}	Characteristic Life	Beta	Reference
10x10 mm Flip Chip (Underfilled)	Sn37Pb/Flux Only	-55/125°C			2299		Schubert 2002
10x10 mm Flip Chip (Underfilled)	Sn4.0Ag0.5Cu/Flux Only	-55/125°C			1929		Schubert 2002
10x10 mm Flip Chip (Underfilled)	Sn37Pb/Flux Only	-55/150°C			1864		Schubert 2002
10x10 mm Flip Chip (Underfilled)	Sn4.0Ag0.5Cu/Flux Only	-55/150°C			1237		Schubert 2002
12 mm flexBGA	Sn37Pb/Flux Only	-40/125°C	1845		2328	13.3	NCMS 2001
12 mm flexBGA	Sn4.0Ag0.5Cu/Flux Only	-40/125°C	2108		2966	9.6	NCMS 2001
12 mm flexBGA	Sn37Pb/Flux Only	0/100°C	3418		4730	12.1	NCMS 2001
12 mm flexBGA	Sn4.0Ag0.5Cu/Flux Only	0/100°C	6073		9515	6.4	NCMS 2001
27 mm PBGA256	Sn37Pb/Flux Only	-40/125°C	3395		3798	23.4	NCMS 2001
27 mm PBGA256	Sn4.0Ag0.5Cu/Flux Only	-40/125°C	5196		8083	8.1	NCMS 2001
27 mm PBGA256	Sn37Pb/Flux Only	0/100°C	>10000K				NCMS 2001
27 mm PBGA256	Sn4.0Ag0.5Cu/Flux Only	0/100°C	>10000K				NCMS 2001
27 mm PBGA256	Sn37Pb/Sn37Pb	-55/125°C	3656		Mean 4377	23.4	Romm 2002
27 mm PBGA256	Sn3.9Ag0.6Cu/Sn3.9Ag0.6Cu	-55/125°C	4404		Mean 6442	8.1	Romm 2002
28 mm PBGA256	Sn37Pb/Sn37Pb	0/100°C		5048	12715	4.98	Primavera 2002
28 mm PBGA256	Sn3.8Ag0.7Cu/Sn3.8Ag0.7Cu	0/100°C		5842	14606	5.02	Primavera 2002
28 mm PBGA256	Sn3.5Ag/Sn3.5Ag	0/100°C		7077	24702	3.68	Primavera 2002
28 mm PBGA256	Sn2.5Ag0.8Cu0.5Sb/Sn2.5Ag0.8Cu0.5Sb	0/100°C		2570	15182	2.59	Primavera 2002

Table A-1. Literature Search for Weibull Parameters (Cont'd)

Component	Solder Ball/Paste	Temp Cycle	1st Failure	N _{1%}	Characteristic Life	Beta	Reference
28 mm PBGA256	Sn37Pb/Sn37Pb	-40/125°C (Shock)		4169	5800	13.93	Dunford 2002
28 mm PBGA256	Sn3.8Ag0.7Cu/Sn3.8Ag0.7Cu	-40/125°C (Shock)		4893	6976	12.97	Dunford 2002
28 mm PBGA256	Sn3.5Ag/Sn3.5Ag	-40/125°C (Shock)		4354	6887	10.03	Dunford 2002
35 mm PBGA388	Sn37Pb/Sn37Pb	-40/125°C		1617	2854	8.1	Roubaud 2001
35 mm PBGA388	Sn4.0Ag0.5Cu/Sn4.0Ag0.5Cu	-40/125°C		3122	5548	8.0	Roubaud 2001
35 mm PBGA388	Sn4.0Ag0.5Cu/Sn4.0Ag0.5Cu (Other Side)	-40/125°C		2134	5565	4.8	Roubaud 2001
35 mm PBGA388	Sn3.5Ag/Sn4.0Ag0.5Cu	-40/125°C		2048	6290	4.1	Roubaud 2001
35 mm PBGA388	Sn2.5Ag0.5Cu1Bi/Sn4.0Ag0.5Cu	-40/125°C		2754	6356	5.5	Roubaud 2001
35 mm PBGA388	Sn0.75Cu/Sn4.0Ag0.5Cu	-40/125°C		2746	4412	9.7	Roubaud 2001
35 mm PBGA388	SnPbAg/SnPb	-55/125°C (Shock)		2048	3814	7.4	Swann 2001
35 mm PBGA388	SnAgCu/Sn3.9Ag0.6Cu	-55/125°C (Shock)		2082	4602	5.8	Swann 2001
35 mm PBGA388	SnAg/Sn3.9Ag0.6Cu	-55/125°C (Shock)		3211	5836	7.7	Swann 2001
169CSP	Sn37Pb/Sn37Pb	-40/125°C		968	1944	6.6	NEMI 2002
169CSP	Sn4.0Ag0.5Cu/Sn3.9Ag0.7Cu	-40/125°C		1762	3254	7.5	NEMI 2002
169CSP	Sn37Pb/Sn37Pb	0/100°C		1798	3321	7.5	NEMI 2002
169CSP	Sn4.0Ag0.5Cu/Sn3.9Ag0.7Cu	0/100°C		2717	8343	4.1	NEMI 2002

Table A-1. Literature Search for Weibull Parameters (References)

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Appendix B. Raw Test Data (“Manufactured” Test Vehicles)

Test Vehicle ID	Component	Ref Designator	Cycle When Component Failed	No. of Hits Accumulated Before Channel Was Turned Off
1	TQFP-144	U1	0	0
1	TSOP-50	U26	0	0
1	TQFP-144	U41	0	0
1	CLCC-20	U9	668	1284
1	PLCC-20	U27	0	0
1	BGA-225	U18	0	0
1	TSOP-50	U39	0	0
1	BGA-225	U56	0	0
1	TSOP-50	U40	0	0
1	TQFP-208	U3	0	0
1	CLCC-20	U13	712	2247
1	Hybrid-30	U32	0	0
1	TQFP-208	U57	0	0
1	CLCC-20	U14	799	1292
1	PLCC-20	U15	0	0
1	TSOP-50	U25	0	0
1	Hybrid-30	U50	0	0
1	Hybrid-30	U33	0	0
1	TQFP-144	U58	0	0
1	TSOP-50	U12	0	0
1	CSP-100	U36	0	0
1	BGA-225	U55	0	0
1	CLCC-20	U17	627	3872
1	BGA-225	U2	0	0
1	TQFP-208	U31	0	0
1	CLCC-20	U45	0	0
1	CLCC-20	U46	0	0
1	PLCC-20	U47	0	0
1	CSP-100	U19	0	0
1	TSOP-50	U24	0	0
1	CSP-100	U42	0	0
1	BGA-225	U4	0	0
1	BGA-225	U43	0	0
1	TQFP-144	U20	0	0
1	BGA-225	U21	0	0
1	BGA-225	U44	0	0
1	TSOP-50	U61	0	0
1	PLCC-20	U54	0	0
1	TQFP-208	U48	0	Bad Component
1	TQFP-144	U7	0	0
1	CLCC-20	U22	961	5185
1	TSOP-50	U16	0	0
1	CSP-100	U37	0	0
1	PDIP-20	U11	0	0
1	PDIP-20	U30	0	0
1	PDIP-20	U35	0	0
1	PDIP-20	U38	0	0
1	PDIP-20	U49	0	0
1	PDIP-20	U51	0	0

1	PDIP-20	U59	0	0
1	PDIP-20	U63	0	0
1	BGA-225	U5	0	0
1	BGA-225	U6	0	0
1	TQFP-208	U34	0	0
1	CLCC-20	U52	0	0
1	CLCC-20	U53	964	2897
1	TSOP-50	U62	986	580
1	CSP-100	U60	0	0
1	CLCC-20	U10	0	0
1	PLCC-20	U28	0	0
1	TSOP-50	U29	0	0
1	PDIP-20	U8	0	0
1	PDIP-20	U23	0	0
1	PTH's	PTH's	0	0
10	TQFP-144	U1	0	0
10	TSOP-50	U26	0	0
10	TQFP-144	U41	0	0
10	CLCC-20	U9	817	2461
10	PLCC-20	U27	0	0
10	BGA-225	U18	0	0
10	TSOP-50	U39	0	0
10	BGA-225	U56	0	0
10	TSOP-50	U40	0	0
10	TQFP-208	U3	0	0
10	CLCC-20	U13	761	7611
10	Hybrid-30	U32	0	0
10	TQFP-208	U57	0	0
10	CLCC-20	U14	979	133
10	PLCC-20	U15	0	0
10	TSOP-50	U25	0	0
10	Hybrid-30	U50	0	0
10	Hybrid-30	U33	0	0
10	TQFP-144	U58	0	0
10	TSOP-50	U12	961	2260
10	CSP-100	U36	0	0
10	BGA-225	U55	0	0
10	CLCC-20	U17	995	1079
10	BGA-225	U2	0	0
10	TQFP-208	U31	0	0
10	CLCC-20	U45	0	0
10	CLCC-20	U46	0	0
10	PLCC-20	U47	0	0
10	CSP-100	U19	0	0
10	TSOP-50	U24	0	0
10	CSP-100	U42	0	0
10	BGA-225	U4	0	0
10	BGA-225	U43	0	0
10	TQFP-144	U20	0	0
10	BGA-225	U21	0	0

10	BGA-225	U44	0	0
10	TSOP-50	U61	0	0
10	PLCC-20	U54	0	0
10	TQFP-208	U48	0	0
10	TQFP-144	U7	0	0
10	CLCC-20	U22	784	19700
10	TSOP-50	U16	0	0
10	CSP-100	U37	0	0
10	PDIP-20	U11	0	0
10	PDIP-20	U30	0	0
10	PDIP-20	U35	144	12402
10	PDIP-20	U38	0	0
10	PDIP-20	U49	0	0
10	PDIP-20	U51	0	0
10	PDIP-20	U59	0	0
10	PDIP-20	U63	0	0
10	BGA-225	U5	0	0
10	BGA-225	U6	0	0
10	TQFP-208	U34	0	0
10	CLCC-20	U52	0	0
10	CLCC-20	U53	852	15894
10	TSOP-50	U62	0	0
10	CSP-100	U60	0	0
10	CLCC-20	U10	771	4404
10	PLCC-20	U28	0	0
10	TSOP-50	U29	0	0
10	PDIP-20	U8	0	0
10	PDIP-20	U23	0	0
10	PTH's	PTH's	0	0
80	TQFP-144	U1	0	0
80	TSOP-50	U26	0	0
80	TQFP-144	U41	0	0
80	CLCC-20	U9	673	71
80	PLCC-20	U27	0	0
80	BGA-225	U18	0	0
80	TSOP-50	U39	0	0
80	BGA-225	U56	0	0
80	TSOP-50	U40	0	0
80	TQFP-208	U3	0	0
80	CLCC-20	U13	557	215
80	Hybrid-30	U32	0	0
80	TQFP-208	U57	0	0
80	CLCC-20	U14	709	212
80	PLCC-20	U15	0	0
80	TSOP-50	U25	0	0
80	Hybrid-30	U50	0	0
80	Hybrid-30	U33	0	0
80	TQFP-144	U58	0	0
80	TSOP-50	U12	0	0
80	CSP-100	U36	0	0

80	BGA-225	U55	0	0
80	CLCC-20	U17	562	3116
80	BGA-225	U2	217	4430
80	TQFP-208	U31	0	0
80	CLCC-20	U45	553	90
80	CLCC-20	U46	559	50
80	PLCC-20	U47	0	0
80	CSP-100	U19	0	0
80	TSOP-50	U24	0	0
80	CSP-100	U42	0	0
80	BGA-225	U4	0	0
80	BGA-225	U43	0	0
80	TQFP-144	U20	0	0
80	BGA-225	U21	0	0
80	BGA-225	U44	0	0
80	TSOP-50	U61	0	0
80	PLCC-20	U54	0	0
80	TQFP-208	U48	0	0
80	TQFP-144	U7	0	0
80	CLCC-20	U22	602	5999
80	TSOP-50	U16	0	0
80	CSP-100	U37	0	0
80	PDIP-20	U11	0	0
80	PDIP-20	U30	0	0
80	PDIP-20	U35	0	Bad Component
80	PDIP-20	U38	0	0
80	PDIP-20	U49	0	0
80	PDIP-20	U51	0	0
80	PDIP-20	U59	0	0
80	PDIP-20	U63	0	0
80	BGA-225	U5	0	0
80	BGA-225	U6	0	0
80	TQFP-208	U34	0	0
80	CLCC-20	U52	671	916
80	CLCC-20	U53	712	2323
80	TSOP-50	U62	0	0
80	CSP-100	U60	0	0
80	CLCC-20	U10	708	246
80	PLCC-20	U28	0	0
80	TSOP-50	U29	0	0
80	PDIP-20	U8	0	0
80	PDIP-20	U23	0	0
80	PTH's	PTH's	0	0
81	TQFP-144	U1	0	0
81	TSOP-50	U26	0	0
81	TQFP-144	U41	0	0
81	CLCC-20	U9	632	3251
81	PLCC-20	U27	0	0
81	BGA-225	U18	0	0
81	TSOP-50	U39	0	0

81	BGA-225	U56	443	1759
81	TSOP-50	U40	0	0
81	TQFP-208	U3	0	0
81	CLCC-20	U13	521	2732
81	Hybrid-30	U32	0	0
81	TQFP-208	U57	0	0
81	CLCC-20	U14	625	4393
81	PLCC-20	U15	0	0
81	TSOP-50	U25	278	314
81	Hybrid-30	U50	0	0
81	Hybrid-30	U33	0	0
81	TQFP-144	U58	0	0
81	TSOP-50	U12	880	4488
81	CSP-100	U36	0	0
81	BGA-225	U55	0	0
81	CLCC-20	U17	768	2693
81	BGA-225	U2	0	0
81	TQFP-208	U31	0	0
81	CLCC-20	U45	79	13349
81	CLCC-20	U46	483	586
81	PLCC-20	U47	0	0
81	CSP-100	U19	0	0
81	TSOP-50	U24	229	3166
81	CSP-100	U42	0	0
81	BGA-225	U4	0	0
81	BGA-225	U43	0	0
81	TQFP-144	U20	0	0
81	BGA-225	U21	0	0
81	BGA-225	U44	223	4802
81	TSOP-50	U61	0	0
81	PLCC-20	U54	0	0
81	TQFP-208	U48	0	0
81	TQFP-144	U7	0	0
81	CLCC-20	U22	720	657
81	TSOP-50	U16	986	28
81	CSP-100	U37	0	0
81	PDIP-20	U11	86	12606
81	PDIP-20	U30	0	0
81	PDIP-20	U35	0	0
81	PDIP-20	U38	0	0
81	PDIP-20	U49	0	0
81	PDIP-20	U51	0	0
81	PDIP-20	U59	0	0
81	PDIP-20	U63	0	0
81	BGA-225	U5	0	0
81	BGA-225	U6	0	0
81	TQFP-208	U34	0	0
81	CLCC-20	U52	752	4999
81	CLCC-20	U53	787	2723
81	TSOP-50	U62	0	0

81	CSP-100	U60	0	0
81	CLCC-20	U10	640	2148
81	PLCC-20	U28	0	0
81	TSOP-50	U29	0	0
81	PDIP-20	U8	0	0
81	PDIP-20	U23	0	0
81	PTH's	PTH's	0	0
82	TQFP-144	U1	0	0
82	TSOP-50	U26	972	1943
82	TQFP-144	U41	0	0
82	CLCC-20	U9	681	342
82	PLCC-20	U27	0	0
82	BGA-225	U18	0	0
82	TSOP-50	U39	0	0
82	BGA-225	U56	0	0
82	TSOP-50	U40	0	0
82	TQFP-208	U3	0	0
82	CLCC-20	U13	490	5087
82	Hybrid-30	U32	0	0
82	TQFP-208	U57	0	0
82	CLCC-20	U14	735	384
82	PLCC-20	U15	0	0
82	TSOP-50	U25	144	10510
82	Hybrid-30	U50	0	0
82	Hybrid-30	U33	0	0
82	TQFP-144	U58	192	6871
82	TSOP-50	U12	0	0
82	CSP-100	U36	0	0
82	BGA-225	U55	0	0
82	CLCC-20	U17	587	4809
82	BGA-225	U2	0	0
82	TQFP-208	U31	0	0
82	CLCC-20	U45	392	5179
82	CLCC-20	U46	468	4311
82	PLCC-20	U47	0	0
82	CSP-100	U19	0	0
82	TSOP-50	U24	0	0
82	CSP-100	U42	0	0
82	BGA-225	U4	0	0
82	BGA-225	U43	0	0
82	TQFP-144	U20	0	0
82	BGA-225	U21	162	9728
82	BGA-225	U44	0	0
82	TSOP-50	U61	0	0
82	PLCC-20	U54	0	0
82	TQFP-208	U48	0	0
82	TQFP-144	U7	0	0
82	CLCC-20	U22	711	17589
82	TSOP-50	U16	0	0
82	CSP-100	U37	0	0

82	PDIP-20	U11	0	0
82	PDIP-20	U30	0	0
82	PDIP-20	U35	0	0
82	PDIP-20	U38	0	0
82	PDIP-20	U49	0	0
82	PDIP-20	U51	0	0
82	PDIP-20	U59	0	0
82	PDIP-20	U63	0	0
82	BGA-225	U5	384	5682
82	BGA-225	U6	0	0
82	TQFP-208	U34	0	0
82	CLCC-20	U52	826	228
82	CLCC-20	U53	506	3073
82	TSOP-50	U62	250	2208
82	CSP-100	U60	0	0
82	CLCC-20	U10	442	1453
82	PLCC-20	U28	0	0
82	TSOP-50	U29	0	0
82	PDIP-20	U8	0	0
82	PDIP-20	U23	0	0
82	PTH's	PTH's	0	0
119	TQFP-144	U1	0	0
119	TSOP-50	U26	246	1020
119	TQFP-144	U41	0	0
119	CLCC-20	U9	823	29
119	PLCC-20	U27	0	0
119	BGA-225	U18	0	0
119	TSOP-50	U39	0	0
119	BGA-225	U56	0	0
119	TSOP-50	U40	667	81
119	TQFP-208	U3	0	0
119	CLCC-20	U13	680	438
119	Hybrid-30	U32	0	0
119	TQFP-208	U57	0	0
119	CLCC-20	U14	0	0
119	PLCC-20	U15	0	0
119	TSOP-50	U25	0	0
119	Hybrid-30	U50	0	0
119	Hybrid-30	U33	0	0
119	TQFP-144	U58	0	0
119	TSOP-50	U12	0	0
119	CSP-100	U36	0	0
119	BGA-225	U55	0	0
119	CLCC-20	U17	737	126
119	BGA-225	U2	0	0
119	TQFP-208	U31	0	0
119	CLCC-20	U45	726	417
119	CLCC-20	U46	763	1420
119	PLCC-20	U47	0	0
119	CSP-100	U19	0	0

119	TSOP-50	U24	664	38
119	CSP-100	U42	0	0
119	BGA-225	U4	0	0
119	BGA-225	U43	0	0
119	TQFP-144	U20	0	0
119	BGA-225	U21	0	0
119	BGA-225	U44	0	0
119	TSOP-50	U61	0	0
119	PLCC-20	U54	0	0
119	TQFP-208	U48	0	0
119	TQFP-144	U7	0	0
119	CLCC-20	U22	723	1063
119	TSOP-50	U16	244	446
119	CSP-100	U37	0	0
119	PDIP-20	U11	0	0
119	PDIP-20	U30	0	0
119	PDIP-20	U35	0	0
119	PDIP-20	U38	0	0
119	PDIP-20	U49	0	Bad Component
119	PDIP-20	U51	0	0
119	PDIP-20	U59	0	0
119	PDIP-20	U63	0	0
119	BGA-225	U5	0	0
119	BGA-225	U6	0	0
119	TQFP-208	U34	0	0
119	CLCC-20	U52	0	0
119	CLCC-20	U53	726	1125
119	TSOP-50	U62	641	1511
119	CSP-100	U60	0	0
119	CLCC-20	U10	952	94
119	PLCC-20	U28	0	0
119	TSOP-50	U29	0	0
119	PDIP-20	U8	0	0
119	PDIP-20	U23	0	0
119	PTH's	PTH's	0	0
120	TQFP-144	U1	0	0
120	TSOP-50	U26	418	4601
120	TQFP-144	U41	0	0
120	CLCC-20	U9	836	129
120	PLCC-20	U27	0	0
120	BGA-225	U18	0	0
120	TSOP-50	U39	0	0
120	BGA-225	U56	0	0
120	TSOP-50	U40	482	2703
120	TQFP-208	U3	0	0
120	CLCC-20	U13	754	6757
120	Hybrid-30	U32	0	0
120	TQFP-208	U57	0	0
120	CLCC-20	U14	842	12770
120	PLCC-20	U15	0	0

120	TSOP-50	U25	0	0
120	Hybrid-30	U50	0	0
120	Hybrid-30	U33	0	0
120	TQFP-144	U58	0	0
120	TSOP-50	U12	0	0
120	CSP-100	U36	0	0
120	BGA-225	U55	0	0
120	CLCC-20	U17	798	1261
120	BGA-225	U2	195	6566
120	TQFP-208	U31	0	0
120	CLCC-20	U45	624	3806
120	CLCC-20	U46	675	198
120	PLCC-20	U47	0	0
120	CSP-100	U19	0	0
120	TSOP-50	U24	573	9025
120	CSP-100	U42	0	0
120	BGA-225	U4	0	0
120	BGA-225	U43	0	0
120	TQFP-144	U20	0	0
120	BGA-225	U21	0	0
120	BGA-225	U44	0	0
120	TSOP-50	U61	0	0
120	PLCC-20	U54	0	0
120	TQFP-208	U48	0	0
120	TQFP-144	U7	0	0
120	CLCC-20	U22	725	1111
120	TSOP-50	U16	334	7662
120	CSP-100	U37	0	0
120	PDIP-20	U11	0	0
120	PDIP-20	U30	0	0
120	PDIP-20	U35	0	0
120	PDIP-20	U38	0	0
120	PDIP-20	U49	0	0
120	PDIP-20	U51	0	0
120	PDIP-20	U59	0	0
120	PDIP-20	U63	0	0
120	BGA-225	U5	0	0
120	BGA-225	U6	0	0
120	TQFP-208	U34	0	0
120	CLCC-20	U52	0	0
120	CLCC-20	U53	663	817
120	TSOP-50	U62	471	5729
120	CSP-100	U60	0	0
120	CLCC-20	U10	823	353
120	PLCC-20	U28	0	0
120	TSOP-50	U29	0	0
120	PDIP-20	U8	0	0
120	PDIP-20	U23	0	0
120	PTH's	PTH's	0	0
121	TQFP-144	U1	0	0

121	TSOP-50	U26	365	6628
121	TQFP-144	U41	0	0
121	CLCC-20	U9	784	1314
121	PLCC-20	U27	0	0
121	BGA-225	U18	0	0
121	TSOP-50	U39	0	0
121	BGA-225	U56	0	0
121	TSOP-50	U40	420	2422
121	TQFP-208	U3	0	0
121	CLCC-20	U13	796	1120
121	Hybrid-30	U32	0	0
121	TQFP-208	U57	0	0
121	CLCC-20	U14	0	0
121	PLCC-20	U15	0	0
121	TSOP-50	U25	0	0
121	Hybrid-30	U50	0	0
121	Hybrid-30	U33	0	0
121	TQFP-144	U58	0	0
121	TSOP-50	U12	0	0
121	CSP-100	U36	0	0
121	BGA-225	U55	0	0
121	CLCC-20	U17	820	17
121	BGA-225	U2	0	0
121	TQFP-208	U31	0	0
121	CLCC-20	U45	926	5515
121	CLCC-20	U46	687	6
121	PLCC-20	U47	0	0
121	CSP-100	U19	0	0
121	TSOP-50	U24	534	671
121	CSP-100	U42	0	0
121	BGA-225	U4	0	0
121	BGA-225	U43	0	0
121	TQFP-144	U20	0	0
121	BGA-225	U21	0	0
121	BGA-225	U44	0	0
121	TSOP-50	U61	0	0
121	PLCC-20	U54	0	0
121	TQFP-208	U48	0	0
121	TQFP-144	U7	0	0
121	CLCC-20	U22	822	341
121	TSOP-50	U16	347	8062
121	CSP-100	U37	0	0
121	PDIP-20	U11	0	0
121	PDIP-20	U30	0	0
121	PDIP-20	U35	0	0
121	PDIP-20	U38	0	0
121	PDIP-20	U49	0	0
121	PDIP-20	U51	0	0
121	PDIP-20	U59	0	0
121	PDIP-20	U63	0	0

121	BGA-225	U5	0	0
121	BGA-225	U6	0	0
121	TQFP-208	U34	0	0
121	CLCC-20	U52	0	0
121	CLCC-20	U53	753	7504
121	TSOP-50	U62	419	335
121	CSP-100	U60	0	0
121	CLCC-20	U10	706	1530
121	PLCC-20	U28	0	0
121	TSOP-50	U29	0	0
121	PDIP-20	U8	0	0
121	PDIP-20	U23	0	0
121	PTH's	PTH's	0	0
11	TQFP-144	U1	0	0
11	TSOP-50	U26	0	0
11	TQFP-144	U41	0	0
11	CLCC-20	U9	761	25272
11	PLCC-20	U27	0	0
11	BGA-225	U18	0	0
11	TSOP-50	U39	0	0
11	BGA-225	U56	0	0
11	TSOP-50	U40	0	0
11	TQFP-208	U3	0	0
11	CLCC-20	U13	644	4665
11	Hybrid-30	U32	0	0
11	TQFP-208	U57	0	0
11	CLCC-20	U14	707	10
11	PLCC-20	U15	0	0
11	TSOP-50	U25	0	0
11	Hybrid-30	U50	0	0
11	Hybrid-30	U33	0	0
11	TQFP-144	U58	0	0
11	TSOP-50	U12	0	0
11	CSP-100	U36	0	0
11	BGA-225	U55	0	0
11	CLCC-20	U17	788	23212
11	BGA-225	U2	0	0
11	TQFP-208	U31	0	0
11	CLCC-20	U45	946	3087
11	CLCC-20	U46	982	1180
11	PLCC-20	U47	0	0
11	CSP-100	U19	0	0
11	TSOP-50	U24	0	0
11	CSP-100	U42	0	0
11	BGA-225	U4	0	0
11	BGA-225	U43	0	0
11	TQFP-144	U20	0	0
11	BGA-225	U21	0	0
11	BGA-225	U44	0	0
11	TSOP-50	U61	0	0

11	PLCC-20	U54	0	0
11	TQFP-208	U48	0	0
11	TQFP-144	U7	0	0
11	CLCC-20	U22	844	10405
11	TSOP-50	U16	0	0
11	CSP-100	U37	0	0
11	PDIP-20	U11	0	0
11	PDIP-20	U30	0	0
11	PDIP-20	U35	0	0
11	PDIP-20	U38	0	0
11	PDIP-20	U49	0	0
11	PDIP-20	U51	0	0
11	PDIP-20	U59	0	0
11	PDIP-20	U63	0	0
11	BGA-225	U5	0	0
11	BGA-225	U6	0	0
11	TQFP-208	U34	0	0
11	CLCC-20	U52	0	0
11	CLCC-20	U53	736	25731
11	TSOP-50	U62	0	0
11	CSP-100	U60	0	0
11	CLCC-20	U10	924	7515
11	PLCC-20	U28	0	0
11	TSOP-50	U29	0	0
11	PDIP-20	U8	0	0
11	PDIP-20	U23	0	0
11	PTH's	PTH's	0	0
12	TQFP-144	U1	0	0
12	TSOP-50	U26	0	0
12	TQFP-144	U41	0	0
12	CLCC-20	U9	0	0
12	PLCC-20	U27	0	0
12	BGA-225	U18	0	0
12	TSOP-50	U39	0	0
12	BGA-225	U56	0	0
12	TSOP-50	U40	0	0
12	TQFP-208	U3	0	0
12	CLCC-20	U13	835	12097
12	Hybrid-30	U32	0	0
12	TQFP-208	U57	0	0
12	CLCC-20	U14	814	13572
12	PLCC-20	U15	0	0
12	TSOP-50	U25	0	0
12	Hybrid-30	U50	0	0
12	Hybrid-30	U33	0	0
12	TQFP-144	U58	0	0
12	TSOP-50	U12	0	0
12	CSP-100	U36	0	0
12	BGA-225	U55	0	0
12	CLCC-20	U17	834	11782

12	BGA-225	U2	0	0
12	TQFP-208	U31	0	0
12	CLCC-20	U45	878	9196
12	CLCC-20	U46	882	8024
12	PLCC-20	U47	0	0
12	CSP-100	U19	0	0
12	TSOP-50	U24	0	0
12	CSP-100	U42	0	0
12	BGA-225	U4	0	0
12	BGA-225	U43	0	0
12	TQFP-144	U20	0	0
12	BGA-225	U21	0	0
12	BGA-225	U44	0	0
12	TSOP-50	U61	0	0
12	PLCC-20	U54	0	0
12	TQFP-208	U48	0	0
12	TQFP-144	U7	0	0
12	CLCC-20	U22	0	0
12	TSOP-50	U16	0	0
12	CSP-100	U37	0	0
12	PDIP-20	U11	0	0
12	PDIP-20	U30	0	0
12	PDIP-20	U35	0	0
12	PDIP-20	U38	0	0
12	PDIP-20	U49	0	0
12	PDIP-20	U51	0	0
12	PDIP-20	U59	0	0
12	PDIP-20	U63	0	Bad Component
12	BGA-225	U5	0	0
12	BGA-225	U6	0	0
12	TQFP-208	U34	0	0
12	CLCC-20	U52	0	0
12	CLCC-20	U53	0	0
12	TSOP-50	U62	0	0
12	CSP-100	U60	0	0
12	CLCC-20	U10	0	0
12	PLCC-20	U28	0	0
12	TSOP-50	U29	0	0
12	PDIP-20	U8	0	0
12	PDIP-20	U23	0	0
12	PTH's	PTH's	0	0
14	TQFP-144	U1	0	0
14	TSOP-50	U26	0	0
14	TQFP-144	U41	0	0
14	CLCC-20	U9	901	3977
14	PLCC-20	U27	0	0
14	BGA-225	U18	0	0
14	TSOP-50	U39	0	0
14	BGA-225	U56	0	0
14	TSOP-50	U40	0	0

14	TQFP-208	U3	0	0
14	CLCC-20	U13	807	14944
14	Hybrid-30	U32	0	0
14	TQFP-208	U57	0	0
14	CLCC-20	U14	651	4421
14	PLCC-20	U15	0	0
14	TSOP-50	U25	0	0
14	Hybrid-30	U50	0	0
14	Hybrid-30	U33	0	0
14	TQFP-144	U58	0	0
14	TSOP-50	U12	0	0
14	CSP-100	U36	0	0
14	BGA-225	U55	0	0
14	CLCC-20	U17	818	20898
14	BGA-225	U2	0	0
14	TQFP-208	U31	0	0
14	CLCC-20	U45	824	13080
14	CLCC-20	U46	914	6282
14	PLCC-20	U47	0	0
14	CSP-100	U19	0	0
14	TSOP-50	U24	0	0
14	CSP-100	U42	0	0
14	BGA-225	U4	0	0
14	BGA-225	U43	0	0
14	TQFP-144	U20	0	0
14	BGA-225	U21	0	0
14	BGA-225	U44	0	0
14	TSOP-50	U61	0	0
14	PLCC-20	U54	0	0
14	TQFP-208	U48	0	0
14	TQFP-144	U7	0	0
14	CLCC-20	U22	0	0
14	TSOP-50	U16	0	0
14	CSP-100	U37	0	0
14	PDIP-20	U11	0	0
14	PDIP-20	U30	0	0
14	PDIP-20	U35	0	0
14	PDIP-20	U38	0	0
14	PDIP-20	U49	0	0
14	PDIP-20	U51	0	0
14	PDIP-20	U59	0	0
14	PDIP-20	U63	0	0
14	BGA-225	U5	0	0
14	BGA-225	U6	0	0
14	TQFP-208	U34	0	0
14	CLCC-20	U52	0	0
14	CLCC-20	U53	0	0
14	TSOP-50	U62	0	0
14	CSP-100	U60	0	0
14	CLCC-20	U10	773	16767

14	PLCC-20	U28	0	0
14	TSOP-50	U29	0	0
14	PDIP-20	U8	0	0
14	PDIP-20	U23	935	4473
14	PTH's	PTH's	0	0
83	TQFP-144	U1	0	0
83	TSOP-50	U26	0	0
83	TQFP-144	U41	0	0
83	CLCC-20	U9	577	7939
83	PLCC-20	U27	0	0
83	BGA-225	U18	0	0
83	TSOP-50	U39	0	0
83	BGA-225	U56	0	0
83	TSOP-50	U40	0	0
83	TQFP-208	U3	0	0
83	CLCC-20	U13	559	8052
83	Hybrid-30	U32	0	0
83	TQFP-208	U57	0	0
83	CLCC-20	U14	652	885
83	PLCC-20	U15	0	0
83	TSOP-50	U25	0	0
83	Hybrid-30	U50	0	0
83	Hybrid-30	U33	0	0
83	TQFP-144	U58	0	0
83	TSOP-50	U12	993	166
83	CSP-100	U36	0	0
83	BGA-225	U55	0	0
83	CLCC-20	U17	605	1214
83	BGA-225	U2	0	0
83	TQFP-208	U31	0	0
83	CLCC-20	U45	740	20476
83	CLCC-20	U46	747	16226
83	PLCC-20	U47	0	0
83	CSP-100	U19	0	0
83	TSOP-50	U24	0	0
83	CSP-100	U42	0	0
83	BGA-225	U4	0	0
83	BGA-225	U43	0	0
83	TQFP-144	U20	0	0
83	BGA-225	U21	0	0
83	BGA-225	U44	0	0
83	TSOP-50	U61	0	0
83	PLCC-20	U54	0	0
83	TQFP-208	U48	0	0
83	TQFP-144	U7	0	0
83	CLCC-20	U22	731	17466
83	TSOP-50	U16	0	0
83	CSP-100	U37	0	0
83	PDIP-20	U11	0	0
83	PDIP-20	U30	0	0

83	PDIP-20	U35	0	0
83	PDIP-20	U38	0	0
83	PDIP-20	U49	0	0
83	PDIP-20	U51	0	0
83	PDIP-20	U59	0	0
83	PDIP-20	U63	0	0
83	BGA-225	U5	0	0
83	BGA-225	U6	0	0
83	TQFP-208	U34	0	0
83	CLCC-20	U52	799	12086
83	CLCC-20	U53	647	1094
83	TSOP-50	U62	0	0
83	CSP-100	U60	0	0
83	CLCC-20	U10	623	4348
83	PLCC-20	U28	0	0
83	TSOP-50	U29	0	0
83	PDIP-20	U8	0	0
83	PDIP-20	U23	0	0
83	PTH's	PTH's	0	0
84	TQFP-144	U1	0	0
84	TSOP-50	U26	821	7181
84	TQFP-144	U41	0	0
84	CLCC-20	U9	518	9
84	PLCC-20	U27	0	0
84	BGA-225	U18	0	0
84	TSOP-50	U39	0	0
84	BGA-225	U56	0	0
84	TSOP-50	U40	0	0
84	TQFP-208	U3	0	0
84	CLCC-20	U13	404	3203
84	Hybrid-30	U32	0	0
84	TQFP-208	U57	0	0
84	CLCC-20	U14	462	2909
84	PLCC-20	U15	0	0
84	TSOP-50	U25	0	0
84	Hybrid-30	U50	0	0
84	Hybrid-30	U33	0	0
84	TQFP-144	U58	0	0
84	TSOP-50	U12	0	0
84	CSP-100	U36	0	0
84	BGA-225	U55	0	0
84	CLCC-20	U17	643	4094
84	BGA-225	U2	0	0
84	TQFP-208	U31	0	0
84	CLCC-20	U45	601	8416
84	CLCC-20	U46	484	2852
84	PLCC-20	U47	0	0
84	CSP-100	U19	0	0
84	TSOP-50	U24	0	0
84	CSP-100	U42	0	0

84	BGA-225	U4	0	0
84	BGA-225	U43	0	0
84	TQFP-144	U20	0	0
84	BGA-225	U21	847	11693
84	BGA-225	U44	0	0
84	TSOP-50	U61	0	0
84	PLCC-20	U54	0	0
84	TQFP-208	U48	0	0
84	TQFP-144	U7	0	0
84	CLCC-20	U22	424	5122
84	TSOP-50	U16	0	0
84	CSP-100	U37	0	0
84	PDIP-20	U11	0	0
84	PDIP-20	U30	0	0
84	PDIP-20	U35	0	0
84	PDIP-20	U38	0	0
84	PDIP-20	U49	0	0
84	PDIP-20	U51	0	0
84	PDIP-20	U59	0	0
84	PDIP-20	U63	0	0
84	BGA-225	U5	0	Bad Component
84	BGA-225	U6	0	0
84	TQFP-208	U34	0	0
84	CLCC-20	U52	627	716
84	CLCC-20	U53	548	6725
84	TSOP-50	U62	0	0
84	CSP-100	U60	0	0
84	CLCC-20	U10	509	705
84	PLCC-20	U28	0	0
84	TSOP-50	U29	923	4971
84	PDIP-20	U8	0	0
84	PDIP-20	U23	0	0
84	PTH's	PTH's	0	0
122	TQFP-144	U1	0	0
122	TSOP-50	U26	441	7985
122	TQFP-144	U41	0	0
122	CLCC-20	U9	657	2824
122	PLCC-20	U27	0	0
122	BGA-225	U18	0	0
122	TSOP-50	U39	0	0
122	BGA-225	U56	0	0
122	TSOP-50	U40	513	101
122	TQFP-208	U3	0	0
122	CLCC-20	U13	758	14227
122	Hybrid-30	U32	0	0
122	TQFP-208	U57	0	0
122	CLCC-20	U14	858	7701
122	PLCC-20	U15	0	0
122	TSOP-50	U25	0	0
122	Hybrid-30	U50	0	0

122	Hybrid-30	U33	0	0
122	TQFP-144	U58	0	0
122	TSOP-50	U12	0	0
122	CSP-100	U36	0	0
122	BGA-225	U55	0	0
122	CLCC-20	U17	747	6056
122	BGA-225	U2	0	0
122	TQFP-208	U31	0	0
122	CLCC-20	U45	741	8561
122	CLCC-20	U46	707	44
122	PLCC-20	U47	0	0
122	CSP-100	U19	0	0
122	TSOP-50	U24	438	447
122	CSP-100	U42	0	0
122	BGA-225	U4	0	0
122	BGA-225	U43	0	0
122	TQFP-144	U20	0	0
122	BGA-225	U21	0	0
122	BGA-225	U44	0	0
122	TSOP-50	U61	0	0
122	PLCC-20	U54	0	0
122	TQFP-208	U48	0	0
122	TQFP-144	U7	0	0
122	CLCC-20	U22	991	450
122	TSOP-50	U16	174	32754
122	CSP-100	U37	0	0
122	PDIP-20	U11	0	0
122	PDIP-20	U30	0	0
122	PDIP-20	U35	0	0
122	PDIP-20	U38	0	0
122	PDIP-20	U49	0	0
122	PDIP-20	U51	0	0
122	PDIP-20	U59	0	0
122	PDIP-20	U63	0	0
122	BGA-225	U5	0	0
122	BGA-225	U6	0	0
122	TQFP-208	U34	0	0
122	CLCC-20	U52	744	19168
122	CLCC-20	U53	849	7685
122	TSOP-50	U62	548	5823
122	CSP-100	U60	0	0
122	CLCC-20	U10	525	7216
122	PLCC-20	U28	0	0
122	TSOP-50	U29	0	0
122	PDIP-20	U8	0	0
122	PDIP-20	U23	0	0
122	PTH's	PTH's	0	0
123	TQFP-144	U1	0	0
123	TSOP-50	U26	211	31758
123	TQFP-144	U41	0	0

123	CLCC-20	U9	697	182
123	PLCC-20	U27	0	0
123	BGA-225	U18	0	0
123	TSOP-50	U39	0	0
123	BGA-225	U56	0	0
123	TSOP-50	U40	522	10230
123	TQFP-208	U3	0	0
123	CLCC-20	U13	574	7810
123	Hybrid-30	U32	0	0
123	TQFP-208	U57	0	0
123	CLCC-20	U14	807	12334
123	PLCC-20	U15	0	0
123	TSOP-50	U25	0	0
123	Hybrid-30	U50	0	0
123	Hybrid-30	U33	0	0
123	TQFP-144	U58	0	0
123	TSOP-50	U12	0	0
123	CSP-100	U36	0	0
123	BGA-225	U55	0	0
123	CLCC-20	U17	814	6162
123	BGA-225	U2	0	0
123	TQFP-208	U31	0	0
123	CLCC-20	U45	654	289
123	CLCC-20	U46	791	11253
123	PLCC-20	U47	0	0
123	CSP-100	U19	0	0
123	TSOP-50	U24	603	677
123	CSP-100	U42	0	0
123	BGA-225	U4	0	0
123	BGA-225	U43	0	0
123	TQFP-144	U20	0	0
123	BGA-225	U21	0	0
123	BGA-225	U44	0	0
123	TSOP-50	U61	0	0
123	PLCC-20	U54	0	0
123	TQFP-208	U48	0	0
123	TQFP-144	U7	0	0
123	CLCC-20	U22	820	11521
123	TSOP-50	U16	181	32072
123	CSP-100	U37	0	0
123	PDIP-20	U11	0	0
123	PDIP-20	U30	0	0
123	PDIP-20	U35	0	0
123	PDIP-20	U38	0	0
123	PDIP-20	U49	0	0
123	PDIP-20	U51	0	0
123	PDIP-20	U59	0	0
123	PDIP-20	U63	0	0
123	BGA-225	U5	0	0
123	BGA-225	U6	0	0

123	TQFP-208	U34	0	0
123	CLCC-20	U52	622	2090
123	CLCC-20	U53	997	7
123	TSOP-50	U62	467	1026
123	CSP-100	U60	0	0
123	CLCC-20	U10	980	111
123	PLCC-20	U28	0	0
123	TSOP-50	U29	0	0
123	PDIP-20	U8	0	0
123	PDIP-20	U23	0	0
123	PTH's	PTH's	0	0
80	Resistor	R1	0	0
80	Resistor	R2	0	0
80	Resistor	R3	0	0
80	Resistor	R4	0	0
80	Resistor	R5	0	0
80	Resistor	R6	0	0
80	Resistor	R7	0	0
80	Resistor	R8	0	0
80	Resistor	R9	0	0
80	Resistor	R10	0	0
81	Resistor	R1	0	0
81	Resistor	R2	0	0
81	Resistor	R3	0	0
81	Resistor	R4	0	0
81	Resistor	R5	0	0
81	Resistor	R6	0	0
81	Resistor	R7	0	0
81	Resistor	R8	0	0
81	Resistor	R9	0	0
81	Resistor	R10	0	0
119	Resistor	R1	0	0
119	Resistor	R2	0	0
119	Resistor	R3	0	0
119	Resistor	R4	0	0
119	Resistor	R5	0	0
119	Resistor	R6	0	0
119	Resistor	R7	0	0
119	Resistor	R8	0	0
119	Resistor	R9	0	0
119	Resistor	R10	0	0
120	Resistor	R1	0	0
120	Resistor	R2	0	0
120	Resistor	R3	0	0
120	Resistor	R4	0	0
120	Resistor	R5	0	0
120	Resistor	R6	0	0
120	Resistor	R7	0	0
120	Resistor	R8	0	0
120	Resistor	R9	0	0

120	Resistor	R10	0	0
1	Resistor	R1	0	0
1	Resistor	R2	0	0
1	Resistor	R3	0	0
1	Resistor	R4	0	0
1	Resistor	R5	0	0
1	Resistor	R6	0	0
1	Resistor	R7	0	0
1	Resistor	R8	0	0
1	Resistor	R9	0	0
1	Resistor	R10	0	0
10	Resistor	R1	0	0
10	Resistor	R2	0	0
10	Resistor	R3	0	0
10	Resistor	R4	0	0
10	Resistor	R5	0	0
10	Resistor	R6	0	0
10	Resistor	R7	0	0
10	Resistor	R8	0	0
10	Resistor	R9	0	0
10	Resistor	R10	0	0

Appendix C. Raw Test Data (“Rework” Test Vehicles)

Test Vehicle ID	Component	Ref Designator	Cycle When Component Failed	No. of Hits Accumulated Before Channel Was Turned Off
51	TQFP-144	U1	0	0
51	TSOP-50	U26	0	0
51	TQFP-144	U41	0	0
51	CLCC-20	U9	851	213
51	PLCC-20	U27	0	0
51	BGA-225	U18	0	0
51	TSOP-50	U39	0	0
51	BGA-225	U56	0	0
51	TSOP-50	U40	0	0
51	TQFP-208	U3	0	0
51	CLCC-20	U13	0	0
51	Hybrid-30	U32	0	0
51	TQFP-208	U57	0	0
51	CLCC-20	U14	897	2864
51	PLCC-20	U15	0	0
51	TSOP-50	U25	0	0
51	Hybrid-30	U50	0	0
51	Hybrid-30	U33	0	0
51	TQFP-144	U58	0	0
51	TSOP-50	U12	966	52
51	CSP-100	U36	0	0
51	BGA-225	U55	0	0
51	CLCC-20	U17	0	0
51	BGA-225	U2	0	0
51	TQFP-208	U31	0	0
51	CLCC-20	U45	0	0
51	CLCC-20	U46	0	0
51	PLCC-20	U47	0	0
51	CSP-100	U19	0	0
51	TSOP-50	U24	0	0
51	CSP-100	U42	0	0
51	BGA-225	U4	0	0
51	BGA-225	U43	0	0
51	TQFP-144	U20	0	0
51	BGA-225	U21	0	0
51	BGA-225	U44	0	0
51	TSOP-50	U61	0	0
51	PLCC-20	U54	0	0
51	TQFP-208	U48	0	0
51	TQFP-144	U7	0	0
51	CLCC-20	U22	916	2330
51	TSOP-50	U16	0	0
51	CSP-100	U37	0	0
51	PDIP-20	U11	0	0
51	PDIP-20	U30	0	0
51	PDIP-20	U35	0	0
51	PDIP-20	U38	0	0
51	PDIP-20	U49	0	0
51	PDIP-20	U51	0	0
51	PDIP-20	U59	0	0

51	PDIP-20	U59	0	0
51	PDIP-20	U63	0	0
51	BGA-225	U5	0	0
51	BGA-225	U6	0	0
51	TQFP-208	U34	0	0
51	CLCC-20	U52	0	0
51	CLCC-20	U53	981	919
51	TSOP-50	U62	0	0
51	CSP-100	U60	0	0
51	CLCC-20	U10	752	4297
51	PLCC-20	U28	0	0
51	TSOP-50	U29	961	2622
51	PDIP-20	U8	0	0
51	PDIP-20	U23	0	0
51	PTH's	PTH's	0	0
52	TQFP-144	U1	0	0
52	TSOP-50	U26	972	1017
52	TQFP-144	U41	0	0
52	CLCC-20	U9	928	4123
52	PLCC-20	U27	0	0
52	BGA-225	U18	0	0
52	TSOP-50	U39	0	0
52	BGA-225	U56	0	0
52	TSOP-50	U40	0	0
52	TQFP-208	U3	0	0
52	CLCC-20	U13	790	1560
52	Hybrid-30	U32	0	0
52	TQFP-208	U57	0	0
52	CLCC-20	U14	804	631
52	PLCC-20	U15	0	0
52	TSOP-50	U25	627	2310
52	Hybrid-30	U50	0	0
52	Hybrid-30	U33	0	0
52	TQFP-144	U58	0	0
52	TSOP-50	U12	415	5906
52	CSP-100	U36	0	0
52	BGA-225	U55	0	0
52	CLCC-20	U17	946	3286
52	BGA-225	U2	0	0
52	TQFP-208	U31	0	0
52	CLCC-20	U45	0	0
52	CLCC-20	U46	957	2894
52	PLCC-20	U47	0	0
52	CSP-100	U19	0	0
52	TSOP-50	U24	0	0
52	CSP-100	U42	0	0
52	BGA-225	U4	0	0
52	BGA-225	U43	0	0
52	TQFP-144	U20	0	0
52	BGA-225	U21	0	0

52	BGA-225	U44	0	0
52	TSOP-50	U61	0	0
52	PLCC-20	U54	0	0
52	TQFP-208	U48	0	0
52	TQFP-144	U7	0	0
52	CLCC-20	U22	910	5257
52	TSOP-50	U16	0	0
52	CSP-100	U37	0	0
52	PDIP-20	U11	0	0
52	PDIP-20	U30	0	0
52	PDIP-20	U35	0	0
52	PDIP-20	U38	0	0
52	PDIP-20	U49	0	0
52	PDIP-20	U51	0	0
52	PDIP-20	U59	0	0
52	PDIP-20	U63	0	0
52	BGA-225	U5	0	0
52	BGA-225	U6	0	0
52	TQFP-208	U34	0	0
52	CLCC-20	U52	968	1102
52	CLCC-20	U53	0	0
52	TSOP-50	U62	995	121
52	CSP-100	U60	0	0
52	CLCC-20	U10	807	263
52	PLCC-20	U28	0	0
52	TSOP-50	U29	994	245
52	PDIP-20	U8	0	0
52	PDIP-20	U23	0	0
52	PTH's	PTH's	0	0
158	TQFP-144	U1	0	0
158	TSOP-50	U26	854	611
158	TQFP-144	U41	0	0
158	CLCC-20	U9	544	1238
158	PLCC-20	U27	0	0
158	BGA-225	U18	0	0
158	TSOP-50	U39	0	0
158	BGA-225	U56	0	0
158	TSOP-50	U40	0	0
158	TQFP-208	U3	313	6168
158	CLCC-20	U13	553	1006
158	Hybrid-30	U32	0	0
158	TQFP-208	U57	0	0
158	CLCC-20	U14	563	192
158	PLCC-20	U15	0	0
158	TSOP-50	U25	0	0
158	Hybrid-30	U50	0	0
158	Hybrid-30	U33	0	0
158	TQFP-144	U58	0	0
158	TSOP-50	U12	880	684
158	CSP-100	U36	0	0

158	BGA-225	U55	0	0
158	CLCC-20	U17	555	633
158	BGA-225	U2	316	4382
158	TQFP-208	U31	0	0
158	CLCC-20	U45	507	1223
158	CLCC-20	U46	642	986
158	PLCC-20	U47	0	0
158	CSP-100	U19	0	0
158	TSOP-50	U24	0	0
158	CSP-100	U42	0	0
158	BGA-225	U4	0	0
158	BGA-225	U43	0	0
158	TQFP-144	U20	0	0
158	BGA-225	U21	696	4049
158	BGA-225	U44	0	0
158	TSOP-50	U61	0	0
158	PLCC-20	U54	0	0
158	TQFP-208	U48	0	0
158	TQFP-144	U7	0	0
158	CLCC-20	U22	486	3182
158	TSOP-50	U16	0	0
158	CSP-100	U37	0	0
158	PDIP-20	U11	0	0
158	PDIP-20	U30	0	0
158	PDIP-20	U35	0	0
158	PDIP-20	U38	0	0
158	PDIP-20	U49	0	0
158	PDIP-20	U51	0	0
158	PDIP-20	U59	0	0
158	PDIP-20	U63	0	0
158	BGA-225	U5	0	0
158	BGA-225	U6	0	0
158	TQFP-208	U34	0	0
158	CLCC-20	U52	518	133
158	CLCC-20	U53	616	3435
158	TSOP-50	U62	0	0
158	CSP-100	U60	0	0
158	CLCC-20	U10	432	3401
158	PLCC-20	U28	0	0
158	TSOP-50	U29	0	0
158	PDIP-20	U8	0	0
158	PDIP-20	U23	0	0
158	PTH's	PTH's	0	0
159	TQFP-144	U1	0	0
159	TSOP-50	U26	0	0
159	TQFP-144	U41	0	0
159	CLCC-20	U9	435	3426
159	PLCC-20	U27	0	0
159	BGA-225	U18	0	0
159	TSOP-50	U39	0	0

159	TSOP-50	U40	908	1592
159	TQFP-208	U3	286	13778
159	CLCC-20	U13	509	56
159	Hybrid-30	U32	0	0
159	TQFP-208	U57	0	0
159	CLCC-20	U14	736	5823
159	PLCC-20	U15	0	0
159	TSOP-50	U25	0	0
159	Hybrid-30	U50	0	0
159	Hybrid-30	U33	0	0
159	TQFP-144	U58	0	0
159	TSOP-50	U12	0	0
159	CSP-100	U36	0	0
159	BGA-225	U55	0	0
159	CLCC-20	U17	640	1977
159	BGA-225	U2	727	4710
159	TQFP-208	U31	0	0
159	CLCC-20	U45	438	3588
159	CLCC-20	U46	570	71
159	PLCC-20	U47	0	0
159	CSP-100	U19	0	0
159	TSOP-50	U24	925	1804
159	CSP-100	U42	0	0
159	BGA-225	U4	0	0
159	BGA-225	U43	0	0
159	TQFP-144	U20	0	0
159	BGA-225	U21	0	0
159	BGA-225	U44	0	0
159	TSOP-50	U61	0	0
159	PLCC-20	U54	0	0
159	TQFP-208	U48	0	0
159	TQFP-144	U7	0	0
159	CLCC-20	U22	347	8940
159	TSOP-50	U16	0	0
159	CSP-100	U37	0	0
159	PDIP-20	U11	0	0
159	PDIP-20	U30	0	0
159	PDIP-20	U35	0	0
159	PDIP-20	U38	0	0
159	PDIP-20	U49	0	0
159	PDIP-20	U51	0	0
159	PDIP-20	U59	0	0
159	PDIP-20	U63	0	0
159	BGA-225	U5	0	0
159	BGA-225	U6	0	0
159	TQFP-208	U34	0	0
159	CLCC-20	U52	797	982
159	CLCC-20	U53	940	4511
159	TSOP-50	U62	0	0

159	CSP-100	U60	0	0
159	CLCC-20	U10	496	3017
159	PLCC-20	U28	0	0
159	TSOP-50	U29	0	0
159	PDIP-20	U8	0	0
159	PDIP-20	U23	0	0
159	PTH's	PTH's	0	0
160	TQFP-144	U1	0	0
160	TSOP-50	U26	0	0
160	TQFP-144	U41	0	0
160	CLCC-20	U9	449	2422
160	PLCC-20	U27	0	0
160	BGA-225	U18	0	0
160	TSOP-50	U39	801	785
160	BGA-225	U56	0	0
160	TSOP-50	U40	0	0
160	TQFP-208	U3	256	2957
160	CLCC-20	U13	485	3811
160	Hybrid-30	U32	0	0
160	TQFP-208	U57	0	0
160	CLCC-20	U14	617	3533
160	PLCC-20	U15	0	0
160	TSOP-50	U25	783	81
160	Hybrid-30	U50	0	0
160	Hybrid-30	U33	0	0
160	TQFP-144	U58	0	0
160	TSOP-50	U12	0	0
160	CSP-100	U36	0	0
160	BGA-225	U55	0	0
160	CLCC-20	U17	496	2041
160	BGA-225	U2	0	0
160	TQFP-208	U31	0	0
160	CLCC-20	U45	497	355
160	CLCC-20	U46	670	17329
160	PLCC-20	U47	0	0
160	CSP-100	U19	0	0
160	TSOP-50	U24	829	1574
160	CSP-100	U42	0	0
160	BGA-225	U4	0	0
160	BGA-225	U43	0	0
160	TQFP-144	U20	0	0
160	BGA-225	U21	0	0
160	BGA-225	U44	0	0
160	TSOP-50	U61	0	0
160	PLCC-20	U54	0	0
160	TQFP-208	U48	0	0
160	TQFP-144	U7	0	0
160	CLCC-20	U22	561	57078
160	TSOP-50	U16	0	0
160	CSP-100	U37	0	0

160	PDIP-20	U30	0	0
160	PDIP-20	U35	0	0
160	PDIP-20	U38	0	0
160	PDIP-20	U49	0	0
160	PDIP-20	U51	0	0
160	PDIP-20	U59	0	0
160	PDIP-20	U63	0	0
160	BGA-225	U5	0	0
160	BGA-225	U6	842	1565
160	TQFP-208	U34	0	0
160	CLCC-20	U52	622	3970
160	CLCC-20	U53	482	3
160	TSOP-50	U62	891	3338
160	CSP-100	U60	0	0
160	CLCC-20	U10	690	12697
160	PLCC-20	U28	0	0
160	TSOP-50	U29	0	0
160	PDIP-20	U8	0	0
160	PDIP-20	U23	0	0
160	PTH's	PTH's	0	0
186	TQFP-144	U1	0	0
186	TSOP-50	U26	903	3225
186	TQFP-144	U41	0	0
186	CLCC-20	U9	582	5887
186	PLCC-20	U27	0	0
186	BGA-225	U18	0	0
186	TSOP-50	U39	990	423
186	BGA-225	U56	0	0
186	TSOP-50	U40	938	1142
186	TQFP-208	U3	26	20642
186	CLCC-20	U13	431	722
186	Hybrid-30	U32	0	0
186	TQFP-208	U57	0	0
186	CLCC-20	U14	531	2750
186	PLCC-20	U15	0	0
186	TSOP-50	U25	455	163
186	Hybrid-30	U50	0	0
186	Hybrid-30	U33	0	0
186	TQFP-144	U58	0	0
186	TSOP-50	U12	569	3017
186	CSP-100	U36	0	0
186	BGA-225	U55	0	0
186	CLCC-20	U17	425	3520
186	BGA-225	U2	135	8064
186	TQFP-208	U31	0	0
186	CLCC-20	U45	475	415
186	CLCC-20	U46	458	1955
186	PLCC-20	U47	0	0
186	CSP-100	U19	0	0

186	TSOP-50	U24	0	0
186	CSP-100	U42	0	0
186	BGA-225	U4	0	0
186	BGA-225	U43	0	0
186	TQFP-144	U20	0	0
186	BGA-225	U21	0	0
186	BGA-225	U44	0	0
186	TSOP-50	U61	0	0
186	PLCC-20	U54	0	0
186	TQFP-208	U48	0	0
186	TQFP-144	U7	0	0
186	CLCC-20	U22	402	5045
186	TSOP-50	U16	0	0
186	CSP-100	U37	0	0
186	PDIP-20	U11	0	0
186	PDIP-20	U30	0	0
186	PDIP-20	U35	0	0
186	PDIP-20	U38	0	0
186	PDIP-20	U49	0	0
186	PDIP-20	U51	0	0
186	PDIP-20	U59	0	0
186	PDIP-20	U63	0	0
186	BGA-225	U5	418	3626
186	BGA-225	U6	0	0
186	TQFP-208	U34	0	0
186	CLCC-20	U52	654	821
186	CLCC-20	U53	432	3887
186	TSOP-50	U62	0	0
186	CSP-100	U60	0	0
186	CLCC-20	U10	482	29
186	PLCC-20	U28	0	0
186	TSOP-50	U29	988	297
186	PDIP-20	U8	0	0
186	PDIP-20	U23	0	0
186	PTH's	PTH's	0	0
187	TQFP-144	U1	0	0
187	TSOP-50	U26	823	3012
187	TQFP-144	U41	0	0
187	CLCC-20	U9	523	40
187	PLCC-20	U27	0	0
187	BGA-225	U18	0	0
187	TSOP-50	U39	861	259
187	BGA-225	U56	0	0
187	TSOP-50	U40	0	0
187	TQFP-208	U3	32	21235
187	CLCC-20	U13	386	6740
187	Hybrid-30	U32	0	0
187	TQFP-208	U57	0	0
187	CLCC-20	U14	527	679
187	PLCC-20	U15	0	0

187	TSOP-50	U25	194	1194
187	Hybrid-30	U50	0	0
187	Hybrid-30	U33	0	0
187	TQFP-144	U58	0	0
187	TSOP-50	U12	488	816
187	CSP-100	U36	0	0
187	BGA-225	U55	0	0
187	CLCC-20	U17	444	2848
187	BGA-225	U2	398	1984
187	TQFP-208	U31	0	0
187	CLCC-20	U45	769	4099
187	CLCC-20	U46	560	362
187	PLCC-20	U47	0	0
187	CSP-100	U19	0	0
187	TSOP-50	U24	918	4238
187	CSP-100	U42	0	0
187	BGA-225	U4	0	0
187	BGA-225	U43	0	0
187	TQFP-144	U20	0	0
187	BGA-225	U21	0	0
187	BGA-225	U44	0	0
187	TSOP-50	U61	0	0
187	PLCC-20	U54	0	0
187	TQFP-208	U48	0	Bad Component
187	TQFP-144	U7	0	0
187	CLCC-20	U22	863	665
187	TSOP-50	U16	0	0
187	CSP-100	U37	0	0
187	PDIP-20	U11	0	0
187	PDIP-20	U30	0	0
187	PDIP-20	U35	0	0
187	PDIP-20	U38	0	0
187	PDIP-20	U49	0	0
187	PDIP-20	U51	0	0
187	PDIP-20	U59	0	0
187	PDIP-20	U63	0	0
187	BGA-225	U5	882	2998
187	BGA-225	U6	508	561
187	TQFP-208	U34	0	0
187	CLCC-20	U52	555	199
187	CLCC-20	U53	411	5093
187	TSOP-50	U62	996	175
187	CSP-100	U60	0	0
187	CLCC-20	U10	552	1080
187	PLCC-20	U28	0	0
187	TSOP-50	U29	0	0
187	PDIP-20	U8	0	0
187	PDIP-20	U23	0	0
187	PTH's	PTH's	0	0
188	TQFP-144	U1	0	0

188	TSOP-50	U26	718	4868
188	TQFP-144	U41	0	0
188	CLCC-20	U9	634	2173
188	PLCC-20	U27	0	0
188	BGA-225	U18	0	0
188	TSOP-50	U39	0	0
188	BGA-225	U56	0	0
188	TSOP-50	U40	721	5240
188	TQFP-208	U3	48	8345
188	CLCC-20	U13	450	2343
188	Hybrid-30	U32	0	0
188	TQFP-208	U57	0	0
188	CLCC-20	U14	536	2670
188	PLCC-20	U15	0	0
188	TSOP-50	U25	220	964
188	Hybrid-30	U50	0	0
188	Hybrid-30	U33	0	0
188	TQFP-144	U58	0	0
188	TSOP-50	U12	250	303
188	CSP-100	U36	0	0
188	BGA-225	U55	0	0
188	CLCC-20	U17	433	2952
188	BGA-225	U2	321	10097
188	TQFP-208	U31	0	0
188	CLCC-20	U45	811	96
188	CLCC-20	U46	348	10161
188	PLCC-20	U47	0	0
188	CSP-100	U19	0	0
188	TSOP-50	U24	774	294
188	CSP-100	U42	0	0
188	BGA-225	U4	0	0
188	BGA-225	U43	0	0
188	TQFP-144	U20	0	0
188	BGA-225	U21	362	6695
188	BGA-225	U44	0	0
188	TSOP-50	U61	0	0
188	PLCC-20	U54	0	0
188	TQFP-208	U48	0	0
188	TQFP-144	U7	0	0
188	CLCC-20	U22	473	597
188	TSOP-50	U16	915	7185
188	CSP-100	U37	0	0
188	PDIP-20	U11	0	0
188	PDIP-20	U30	0	0
188	PDIP-20	U35	0	Bad Component
188	PDIP-20	U38	0	0
188	PDIP-20	U49	0	0
188	PDIP-20	U51	0	0
188	PDIP-20	U59	0	0
188	PDIP-20	U63	0	0

188	BGA-225	U5	801	826
188	BGA-225	U6	944	750
188	TQFP-208	U34	0	0
188	CLCC-20	U52	519	26
188	CLCC-20	U53	498	1590
188	TSOP-50	U62	0	0
188	CSP-100	U60	0	0
188	CLCC-20	U10	507	910
188	PLCC-20	U28	0	0
188	TSOP-50	U29	0	0
188	PDIP-20	U8	0	0
188	PDIP-20	U23	0	0
188	PTH's	PTH's	0	0
53	TQFP-144	U1	0	0
53	TSOP-50	U26	963	1557
53	TQFP-144	U41	0	0
53	CLCC-20	U9	0	0
53	PLCC-20	U27	0	0
53	BGA-225	U18	0	0
53	TSOP-50	U39	0	0
53	BGA-225	U56	0	0
53	TSOP-50	U40	0	0
53	TQFP-208	U3	0	0
53	CLCC-20	U13	786	1451
53	Hybrid-30	U32	0	0
53	TQFP-208	U57	0	0
53	CLCC-20	U14	0	0
53	PLCC-20	U15	0	0
53	TSOP-50	U25	829	3475
53	Hybrid-30	U50	0	0
53	Hybrid-30	U33	0	0
53	TQFP-144	U58	0	0
53	TSOP-50	U12	840	1668
53	CSP-100	U36	0	0
53	BGA-225	U55	0	0
53	CLCC-20	U17	895	2837
53	BGA-225	U2	0	0
53	TQFP-208	U31	0	0
53	CLCC-20	U45	946	3653
53	CLCC-20	U46	981	482
53	PLCC-20	U47	0	0
53	CSP-100	U19	0	0
53	TSOP-50	U24	932	218
53	CSP-100	U42	0	0
53	BGA-225	U4	0	0
53	BGA-225	U43	0	0
53	TQFP-144	U20	0	0
53	BGA-225	U21	0	0
53	BGA-225	U44	0	0
53	TSOP-50	U61	0	0

53	PLCC-20	U54	0	0
53	TQFP-208	U48	0	0
53	TQFP-144	U7	0	0
53	CLCC-20	U22	0	0
53	TSOP-50	U16	0	0
53	CSP-100	U37	0	0
53	PDIP-20	U11	0	0
53	PDIP-20	U30	0	0
53	PDIP-20	U35	0	0
53	PDIP-20	U38	0	0
53	PDIP-20	U49	0	0
53	PDIP-20	U51	0	0
53	PDIP-20	U59	0	0
53	PDIP-20	U63	0	0
53	BGA-225	U5	0	0
53	BGA-225	U6	0	0
53	TQFP-208	U34	0	0
53	CLCC-20	U52	0	0
53	CLCC-20	U53	0	0
53	TSOP-50	U62	0	0
53	CSP-100	U60	0	0
53	CLCC-20	U10	922	626
53	PLCC-20	U28	0	0
53	TSOP-50	U29	0	0
53	PDIP-20	U8	0	0
53	PDIP-20	U23	0	0
53	PTH's	PTH's	0	0
54	TQFP-144	U1	0	0
54	TSOP-50	U26	839	5877
54	TQFP-144	U41	0	0
54	CLCC-20	U9	730	1697
54	PLCC-20	U27	0	0
54	BGA-225	U18	0	0
54	TSOP-50	U39	886	200
54	BGA-225	U56	0	0
54	TSOP-50	U40	877	877
54	TQFP-208	U3	0	0
54	CLCC-20	U13	533	1984
54	Hybrid-30	U32	0	0
54	TQFP-208	U57	0	0
54	CLCC-20	U14	644	38
54	PLCC-20	U15	0	0
54	TSOP-50	U25	0	0
54	Hybrid-30	U50	0	0
54	Hybrid-30	U33	0	0
54	TQFP-144	U58	0	0
54	TSOP-50	U12	0	0
54	CSP-100	U36	0	0
54	BGA-225	U55	0	0
54	CLCC-20	U17	571	2473

54	BGA-225	U2	0	0
54	TQFP-208	U31	0	0
54	CLCC-20	U45	840	5878
54	CLCC-20	U46	598	1777
54	PLCC-20	U47	0	0
54	CSP-100	U19	0	0
54	TSOP-50	U24	0	0
54	CSP-100	U42	0	0
54	BGA-225	U4	0	0
54	BGA-225	U43	0	0
54	TQFP-144	U20	0	0
54	BGA-225	U21	0	0
54	BGA-225	U44	0	0
54	TSOP-50	U61	0	0
54	PLCC-20	U54	0	0
54	TQFP-208	U48	0	0
54	TQFP-144	U7	0	0
54	CLCC-20	U22	632	38
54	TSOP-50	U16	833	6452
54	CSP-100	U37	0	0
54	PDIP-20	U11	0	0
54	PDIP-20	U30	0	0
54	PDIP-20	U35	0	0
54	PDIP-20	U38	0	0
54	PDIP-20	U49	0	0
54	PDIP-20	U51	0	0
54	PDIP-20	U59	0	0
54	PDIP-20	U63	0	0
54	BGA-225	U5	0	0
54	BGA-225	U6	0	0
54	TQFP-208	U34	0	0
54	CLCC-20	U52	910	2735
54	CLCC-20	U53	899	3043
54	TSOP-50	U62	927	810
54	CSP-100	U60	0	0
54	CLCC-20	U10	714	2900
54	PLCC-20	U28	0	0
54	TSOP-50	U29	837	2752
54	PDIP-20	U8	0	0
54	PDIP-20	U23	0	Bad Component
54	PTH's	PTH's	0	0
55	TQFP-144	U1	0	0
55	TSOP-50	U26	0	0
55	TQFP-144	U41	0	0
55	CLCC-20	U9	753	12
55	PLCC-20	U27	0	0
55	BGA-225	U18	0	0
55	TSOP-50	U39	0	0
55	BGA-225	U56	0	0
55	TSOP-50	U40	0	0

55	TQFP-208	U3	0	0
55	CLCC-20	U13	950	3279
55	Hybrid-30	U32	0	0
55	TQFP-208	U57	0	0
55	CLCC-20	U14	791	285
55	PLCC-20	U15	0	0
55	TSOP-50	U25	596	638
55	Hybrid-30	U50	0	0
55	Hybrid-30	U33	0	0
55	TQFP-144	U58	0	0
55	TSOP-50	U12	0	Bad Component
55	CSP-100	U36	0	0
55	BGA-225	U55	0	0
55	CLCC-20	U17	637	38
55	BGA-225	U2	0	0
55	TQFP-208	U31	0	Bad Component
55	CLCC-20	U45	911	2374
55	CLCC-20	U46	946	3949
55	PLCC-20	U47	0	0
55	CSP-100	U19	0	0
55	TSOP-50	U24	0	0
55	CSP-100	U42	0	0
55	BGA-225	U4	0	0
55	BGA-225	U43	0	0
55	TQFP-144	U20	0	0
55	BGA-225	U21	0	0
55	BGA-225	U44	0	0
55	TSOP-50	U61	0	0
55	PLCC-20	U54	0	0
55	TQFP-208	U48	0	0
55	TQFP-144	U7	0	0
55	CLCC-20	U22	933	432
55	TSOP-50	U16	0	0
55	CSP-100	U37	0	0
55	PDIP-20	U11	0	0
55	PDIP-20	U30	0	0
55	PDIP-20	U35	0	0
55	PDIP-20	U38	0	0
55	PDIP-20	U49	0	0
55	PDIP-20	U51	0	0
55	PDIP-20	U59	0	0
55	PDIP-20	U63	0	0
55	BGA-225	U5	0	0
55	BGA-225	U6	0	0
55	TQFP-208	U34	0	0
55	CLCC-20	U52	955	2426
55	CLCC-20	U53	0	0
55	TSOP-50	U62	951	2862
55	CSP-100	U60	0	0
55	CLCC-20	U10	773	4494

55	PLCC-20	U28	0	0
55	TSOP-50	U29	0	0
55	PDIP-20	U8	0	0
55	PDIP-20	U23	0	0
55	PTH's	PTH's	0	0
161	TQFP-144	U1	0	0
161	TSOP-50	U26	637	37
161	TQFP-144	U41	0	0
161	CLCC-20	U9	356	5129
161	PLCC-20	U27	0	0
161	BGA-225	U18	0	0
161	TSOP-50	U39	956	2412
161	BGA-225	U56	0	0
161	TSOP-50	U40	965	1475
161	TQFP-208	U3	182	2547
161	CLCC-20	U13	374	1575
161	Hybrid-30	U32	0	0
161	TQFP-208	U57	0	0
161	CLCC-20	U14	575	2495
161	PLCC-20	U15	0	0
161	TSOP-50	U25	0	0
161	Hybrid-30	U50	0	0
161	Hybrid-30	U33	0	0
161	TQFP-144	U58	0	0
161	TSOP-50	U12	0	0
161	CSP-100	U36	0	0
161	BGA-225	U55	0	0
161	CLCC-20	U17	397	181
161	BGA-225	U2	0	0
161	TQFP-208	U31	0	0
161	CLCC-20	U45	409	427
161	CLCC-20	U46	433	2305
161	PLCC-20	U47	0	0
161	CSP-100	U19	0	0
161	TSOP-50	U24	0	0
161	CSP-100	U42	0	0
161	BGA-225	U4	0	0
161	BGA-225	U43	0	0
161	TQFP-144	U20	0	0
161	BGA-225	U21	0	0
161	BGA-225	U44	0	0
161	TSOP-50	U61	0	0
161	PLCC-20	U54	0	0
161	TQFP-208	U48	0	0
161	TQFP-144	U7	0	0
161	CLCC-20	U22	424	2947
161	TSOP-50	U16	0	0
161	CSP-100	U37	0	0
161	PDIP-20	U11	0	0
161	PDIP-20	U30	0	0

161	PDIP-20	U35	0	0
161	PDIP-20	U38	0	0
161	PDIP-20	U49	0	0
161	PDIP-20	U51	0	0
161	PDIP-20	U59	0	0
161	PDIP-20	U63	0	0
161	BGA-225	U5	0	0
161	BGA-225	U6	0	0
161	TQFP-208	U34	0	0
161	CLCC-20	U52	447	465
161	CLCC-20	U53	739	218
161	TSOP-50	U62	900	253
161	CSP-100	U60	0	0
161	CLCC-20	U10	315	996
161	PLCC-20	U28	0	0
161	TSOP-50	U29	0	0
161	PDIP-20	U8	0	0
161	PDIP-20	U23	0	0
161	PTH's	PTH's	0	0
162	TQFP-144	U1	0	0
162	TSOP-50	U26	921	1249
162	TQFP-144	U41	0	0
162	CLCC-20	U9	353	4948
162	PLCC-20	U27	0	0
162	BGA-225	U18	0	0
162	TSOP-50	U39	0	0
162	BGA-225	U56	0	0
162	TSOP-50	U40	991	278
162	TQFP-208	U3	788	9
162	CLCC-20	U13	594	1825
162	Hybrid-30	U32	0	0
162	TQFP-208	U57	0	0
162	CLCC-20	U14	634	38
162	PLCC-20	U15	0	0
162	TSOP-50	U25	998	5
162	Hybrid-30	U50	0	0
162	Hybrid-30	U33	0	0
162	TQFP-144	U58	0	0
162	TSOP-50	U12	947	389
162	CSP-100	U36	0	0
162	BGA-225	U55	0	0
162	CLCC-20	U17	403	503
162	BGA-225	U2	0	0
162	TQFP-208	U31	0	0
162	CLCC-20	U45	467	48
162	CLCC-20	U46	453	943
162	PLCC-20	U47	0	0
162	CSP-100	U19	0	0
162	TSOP-50	U24	988	22
162	CSP-100	U42	0	0

162	BGA-225	U4	0	0
162	BGA-225	U43	0	0
162	TQFP-144	U20	0	0
162	BGA-225	U21	669	15614
162	BGA-225	U44	0	0
162	TSOP-50	U61	0	0
162	PLCC-20	U54	0	0
162	TQFP-208	U48	0	0
162	TQFP-144	U7	0	0
162	CLCC-20	U22	521	56796
162	TSOP-50	U16	0	0
162	CSP-100	U37	0	0
162	PDIP-20	U11	0	0
162	PDIP-20	U30	0	0
162	PDIP-20	U35	0	0
162	PDIP-20	U38	0	0
162	PDIP-20	U49	0	0
162	PDIP-20	U51	0	0
162	PDIP-20	U59	0	0
162	PDIP-20	U63	0	0
162	BGA-225	U5	596	9
162	BGA-225	U6	0	0
162	TQFP-208	U34	0	0
162	CLCC-20	U52	568	3620
162	CLCC-20	U53	370	5578
162	TSOP-50	U62	907	1494
162	CSP-100	U60	0	0
162	CLCC-20	U10	387	1085
162	PLCC-20	U28	0	0
162	TSOP-50	U29	0	0
162	PDIP-20	U8	0	0
162	PDIP-20	U23	0	0
162	PTH's	PTH's	0	0
189	TQFP-144	U1	0	0
189	TSOP-50	U26	769	2493
189	TQFP-144	U41	0	0
189	CLCC-20	U9	563	165
189	PLCC-20	U27	0	0
189	BGA-225	U18	0	0
189	TSOP-50	U39	899	982
189	BGA-225	U56	0	0
189	TSOP-50	U40	887	234
189	TQFP-208	U3	186	537
189	CLCC-20	U13	300	1940
189	Hybrid-30	U32	0	0
189	TQFP-208	U57	0	0
189	CLCC-20	U14	650	38
189	PLCC-20	U15	0	0
189	TSOP-50	U25	157	2264
189	Hybrid-30	U50	0	0

189	Hybrid-30	U33	0	0
189	TQFP-144	U58	0	0
189	TSOP-50	U12	381	1109
189	CSP-100	U36	0	0
189	BGA-225	U55	0	0
189	CLCC-20	U17	609	461
189	BGA-225	U2	689	3616
189	TQFP-208	U31	0	0
189	CLCC-20	U45	437	3668
189	CLCC-20	U46	467	43
189	PLCC-20	U47	0	0
189	CSP-100	U19	0	0
189	TSOP-50	U24	805	509
189	CSP-100	U42	0	0
189	BGA-225	U4	0	0
189	BGA-225	U43	691	1509
189	TQFP-144	U20	0	0
189	BGA-225	U21	424	1490
189	BGA-225	U44	582	1661
189	TSOP-50	U61	962	2109
189	PLCC-20	U54	0	0
189	TQFP-208	U48	0	0
189	TQFP-144	U7	0	0
189	CLCC-20	U22	450	906
189	TSOP-50	U16	0	0
189	CSP-100	U37	0	0
189	PDIP-20	U11	0	0
189	PDIP-20	U30	0	0
189	PDIP-20	U35	0	0
189	PDIP-20	U38	0	0
189	PDIP-20	U49	0	0
189	PDIP-20	U51	0	0
189	PDIP-20	U59	0	0
189	PDIP-20	U63	0	0
189	BGA-225	U5	851	55
189	BGA-225	U6	502	3916
189	TQFP-208	U34	0	0
189	CLCC-20	U52	405	887
189	CLCC-20	U53	399	1130
189	TSOP-50	U62	786	1650
189	CSP-100	U60	0	0
189	CLCC-20	U10	334	3699
189	PLCC-20	U28	0	0
189	TSOP-50	U29	0	0
189	PDIP-20	U8	0	0
189	PDIP-20	U23	0	0
189	PTH's	PTH's	0	0
190	TQFP-144	U1	0	0
190	TSOP-50	U26	976	1136
190	TQFP-144	U41	0	0

190	CLCC-20	U9	404	909
190	PLCC-20	U27	0	0
190	BGA-225	U18	0	0
190	TSOP-50	U39	577	2846
190	BGA-225	U56	437	1779
190	TSOP-50	U40	565	1192
190	TQFP-208	U3	17	21313
190	CLCC-20	U13	393	2129
190	Hybrid-30	U32	0	0
190	TQFP-208	U57	0	0
190	CLCC-20	U14	467	11
190	PLCC-20	U15	0	0
190	TSOP-50	U25	433	835
190	Hybrid-30	U50	0	0
190	Hybrid-30	U33	0	0
190	TQFP-144	U58	0	0
190	TSOP-50	U12	453	387
190	CSP-100	U36	0	0
190	BGA-225	U55	0	0
190	CLCC-20	U17	459	282
190	BGA-225	U2	224	168
190	TQFP-208	U31	0	0
190	CLCC-20	U45	321	486
190	CLCC-20	U46	607	495
190	PLCC-20	U47	0	0
190	CSP-100	U19	0	0
190	TSOP-50	U24	760	1119
190	CSP-100	U42	0	0
190	BGA-225	U4	0	0
190	BGA-225	U43	738	467
190	TQFP-144	U20	0	0
190	BGA-225	U21	151	4664
190	BGA-225	U44	326	149
190	TSOP-50	U61	0	0
190	PLCC-20	U54	0	0
190	TQFP-208	U48	0	0
190	TQFP-144	U7	0	0
190	CLCC-20	U22	373	2737
190	TSOP-50	U16	0	0
190	CSP-100	U37	0	0
190	PDIP-20	U11	0	0
190	PDIP-20	U30	0	0
190	PDIP-20	U35	0	0
190	PDIP-20	U38	0	0
190	PDIP-20	U49	0	0
190	PDIP-20	U51	0	0
190	PDIP-20	U59	225	30
190	PDIP-20	U63	0	0
190	BGA-225	U5	240	4084
190	BGA-225	U6	238	4909
190	TQFP-208	U34	0	0
190	CLCC-20	U52	362	5910
190	CLCC-20	U53	306	2914
190	TSOP-50	U62	977	75
190	CSP-100	U60	0	0
190	CLCC-20	U10	502	3940
190	PLCC-20	U28	0	0
190	TSOP-50	U29	853	2101
190	PDIP-20	U8	0	0
190	PDIP-20	U23	0	0
190	PTH's	PTH's	0	0